ational Psychology Monographs

# THE GENERAL VALUE OF VISUAL SENSE TRAINING IN CHILDREN

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# THE GENERAL VALUE OF VISUAL SENSE TRAINING IN CHILDREN

BY

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# EDITOR'S PREFACE

Contributions to the experimental study of the transfer of training (formal discipline) scarcely need either apology or introduction in a period when, despite the considerable amount of investigation, so very much still remains undetermined with respect to the amount of such transfer and the mechanism by means of which it takes place.

The special features of this contribution by Dr. Wang, a Chinese government student at the University of Michigan, lie in the use of school children as subjects and in the use of sense-training as the medium of experimentation. In this latter aspect his study will be particularly welcome from the light it throws upon the issue of sense-training, which is almost a fetish of the adherents of the, at present, so popular Montessori method.

G. M. WHIPPLE.

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# INTRODUCTION

There are two types of disciplinists. There are those of the old type who believe that the mental power developed by the training of one function will benefit equally all other functions. This type is represented by the man who claims that any kind of study, no matter what it may be, will prepare for life, so long as that study is done well. The later type of disciplinist is less sweeping in his claims. He believes that the training of a specific function, such as memorizing poetry, will benefit all other kinds of memories, the general function of memory. This type is represented by the man who advocates studies in schools for the development of the various mental functions: arithmetic develops the power of accuracy; Latin, the power of analysis; sense education, the power of observation. The old type of disciplinist is scarcely to be found among educators of today, but the later type still dominates, in certain respects, the educational world. Many writers have already pointed out instances showing how some of the most prominent educators, both in Europe and America, have overestimated the importance of this type of discipline. Thorndike, Ruediger, Fracker, Winch and others have not only attacked it, but have also demonstrated by experiments the limitations of certain specific functions. These functions are selected from those general functions which we designate as memory, discrimination, or reasoning. The results show that there are many kinds of memories, discriminations and reasonings. One kind of memory, after

much training, may not affect certain other memories at all. The same has been found true in other fields of mental functioning.

It was the purpose of the writer to continue the experimentation within the field of discrimination and, if possible, to contribute something to our knowledge of the extent, amount, and means of generalization, or transfer, upon which points there is as yet no general agreement. By extent of transfer is here meant the range of influence which the training of a specific function has over untrained functions; and by amount of transfer, the aggregate of improvement in any specific untrained function as a result of the training.

With regard to the *extent* of transfer Thorndike says: "Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case."[1] But Fracker denies this by saying: "Improvement in many cases is absolutely greater in amount in the test than in the training."[2] It is evident that this question of the extent of transfer needs further investigation.

With regard to the *amount* of transfer each experiment has shown a different result. This is due partly to different methods of calculation and partly to the testing of different functions. In some experiments adults act as subjects and in others children. In his calculations one experimenter uses points to denote the amount of transfer while others use per cent. Some writers take the improvement of the trained

[1] Thorndike, E. L., *Educational Psychology*, 1903, p. 91.
[2] Fracker, G. C., *Psychological Review Monograph Supplement*, Vol. 9, No. 2, p. 99.

function as the basis of calculation; and others, the record made in the preliminary test. Naturally the results are not uniform. There is a special need just now for standardization in our methods of experimentation as well as in the methods of calculating our results.

With regard to the *means* of transfer different writers seem to have reached different conclusions. To quote Colvin: "The question whether the results are due to functioning of identical elements (Thorndike); to improvement of habitual methods of recording facts (James); to training the attention and will power (Scripture and Davis); to divesting the essential process of the unessential factors, greater habituation and more economical adaptation of attention (Coover and Angell); to the effective use of mental imagery and properly controlled attention (Fracker); to the development of ideals (Bagley, Ruediger, and Ruger); to general improvement in technique of learning, attention and will-power, but chiefly to a sympathetic interaction of allied memory functions (Ebert and Meumann), or to all of these, or to some other factors as yet not analyzed out, will doubtless for a long time offer a fruitful field of inquiry."[3]

The present experiments were undertaken with these different questions in mind. Reaction time is taken throughout to detect temporal differences, which play an important part in sense discrimination of all kinds. Children are employed as subjects, because there is a suspicion among educational psychologists that possibly specific training has a greater value for them than for adults, on account of the faster rate of physical and mental development in childhood. This suspicion

[3] Colvin, S. S., *The Learning Process*, pp. 241–2.

is voiced by Foster who, writing on the effect of practice upon visualizing and upon the reproduction of visual impressions, concludes his article by remarking: "Specific practice is demanded for best results and becomes quickly effective. It seems, therefore, as if the value of formal training of our kind has been overestimated. However, our experiments were made upon adults who were already trained in habits of attentive observation, and we have no right or wish to extend our conclusions in wholesale fashion. It may be that, for immature and untrained persons, practice in visual reproduction might possess a general value that was not discovered under our conditions."[4]

The writer is indebted to Dr. J. F. Shepard, Dr. F. S. Breed, Professor W. B. Pillsbury and Professor A. S. Whitney for their suggestions, supervision and encouragement throughout the work. He wishes to thank the Board of Education of Ann Arbor, Michigan, for giving permission to carry on the work and especially Miss C. L. Dicken, Principal of the W. S. Perry School, and the parents who kindly consented to let their children act as subjects.

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[4] Foster, W. S., The Effect of Practice upon Visualizing and upon the Reproduction of Visual Impressions, *Jour. Educational Psychology*, Vol. 2, p. 21.

## ANALYTICAL REVIEW OF PREVIOUS EXPERIMENTS

The origin of the doctrine of formal discipline dates as far back as Plato, who wrote: "and have you further remarked that those who have the natural talent for calculation are generally quick at every other kind of knowledge; and even the dull if they have an arithmetical training gain in quickness if not in any other way."[5] But it was during the time of the scholastics and humanists that this doctrine reached its zenith. The scholastics regarded the mind as a logical machine for the purpose of grinding out cut-and-dried truth, while the humanists claimed that ancient languages could furnish all the mental nourishment and power necessary for life. The modern criticism of the doctrine was launched by the German Herbartians, who maintained "that since all mental exercise takes its rise in a definite mental content, its character is necessarily determined by its origin."[6] To these people was due the credit for having started the movement toward experimental investigation.

For a chronological review of the experiments which have been performed the reader is referred to Heck's *Mental Discipline and Educational Values;* Thorndike's *Educational Psychology*, Vol. 2; Bagley's *Educative Process*, or Colvin's *The Learning Process*. It would be well for us to take this opportunity to review the experimental methods which seem to demand description. Since people have begun to test the doctrine

[5] Plato, *Republic*, Book 7.

[6] Ruediger, W. C., *Principles of Education*, p. 96.

of formal discipline by controlled experiments, there has been gradually built up a regular method for conducting such experiments. From the work of William James, who performed the first controlled test of the spreading influence of one specially trained memory function upon memory functions of a different content, to the present day, there have been four methods used, each an improvement over its precedessor. The very first used may be called

*The Individual Method*

To William James should be given the credit for first using this method, in which only one person acts as subject, usually the experimenter himself. In James' own words:

> "In order to test the opinion so confidently expressed in the text, I have tried to see whether a certain amount of daily training in learning poetry by heart will shorten the time it takes to learn an entirely different kind of poetry. During eight successive days I learned 158 lines of Victor Hugo's 'Satyr.' The total number of minutes required for this was 131⅚—it should be said that I had learned nothing by heart for many years. I then, working for twenty-odd minutes daily, learned the entire first book of Paradise Lost, occupying 38 days in the process. After this training I went back to Victor Hugo's poem, and found that 158 additional lines (divided exactly as on the former occasion) took me 151½ minutes. In other words, I committed my Victor Hugo to memory before the training at the rate of a line in 50 seconds, after the training at the rate of a line in 57 seconds, just the opposite result from that which the popular view would lead one to expect. But as I was perceptibly fagged with other work at the time of the second batch of Victor Hugo, I thought that might explain the retardation; so I persuaded several other persons to repeat the test."[7]

This method of testing the doctrine of formal discipline has the advantage of direct introspection, especially when the experimenter is a good psychologist. On the other hand, we feel uncertain whether the results obtained will represent the average experience of the

[7] James, Wm., *The Principles of Psychology*, Vol. I, pp. 666–667.

mass. We hesitate to apply such individual conclusions to every-day use, since researches have proved that mental traits vary as much as physical traits. For example, the following table taken from Thorndike,[8] showing the ability of 4th-grade girls in thinking of opposites of words, illustrates the curve of distribution in one mental trait, and shows clearly how wide a range of ability there is in that trait.

| Score Made in Test with Opposites | | Number of Children |
|---|---|---|
| —9 to —5 | by | 3 girls |
| —4 " 0 | " | 5 " |
| 0 " 4 | " | 8 " |
| 5 " 9 | " | 10 " |
| 10 " 14 | " | 33 " |
| 15 " 19 | " | 36 " |
| 20 " 24 | " | 29 " |
| 25 " 29 | " | 16 " |
| 30 " 34 | " | 11 " |
| 35 " 39 | " | 4 " |
| 40 " 44 | " | 3 " |

To eliminate the individual variations, then, a number of subjects are employed, and this may be called the

### *One-Group Method*

One of the first to use this method was Dr. E. L. Thorndike, who has contributed so much to the study of individual differences. He describes his experiment briefly as follows:

"Individuals practiced estimating the areas of rectangles from 10 to 100 sq. cm. in size until a very marked improvement was attained. The improvement in accuracy for areas of the same size but of different shape due to this training was only 44 per cent as great as that for areas of the same shape and size. For areas of the same shape, but from 140–300 sq. cm. in size, the improvement was 30 per cent as great. For areas of different shape and from 140–400 sq. cm. in size, the improvement was 52 per cent as great."[9]

[8] Thorndike, E. L., *Principles of Teaching*, p. 74.
[9] Thorndike, E. L., *Educational Psychology*, Vol. II, p. 397.

The result stated in this experiment was obtained by averaging the totals of the practiced individuals. In this way individual peculiarities are in a measure eliminated. Wherever a large number of subjects are available, the result will be safer.

Though this was an advance in the technique of experimentation, there was still room for improvement. All Thorndike's subjects were given the various tests ("areas of the same size but of different shape," "areas of the same shape but from 140–300 sq. cm. in size," and "areas of different shape and from 140–400 sq. cm. in size") before as well as after the training ("areas of rectangles from 10 to 100 sq. cm. in size") took place. The first or preliminary test really amounts to a training in itself. If this is the case, there is no way to tell how much of the 44, 30 and 52 per cent improvements, respectively, were due to the first test and how much to the training received from the practice in estimating areas of rectangles from 10 to 100 sq. cm. in size. To separate these two factors, improvement due to practice and improvement due to the preliminary test, educators have since introduced the

*Two-Group Method*

The two-group method means, as the name implies, that the subjects to be tested are evenly divided, according to physical and mental development, into two groups. While both groups are tested, first before and then after the practice or training, only one of the groups receives the training. There are several advantages to this method of procedure. By the use of the untrained group the possible effects of the preliminary test, maturation, and incubation are not confused with transfer effects. By a comparison of the

two groups, trained and untrained, the practice effect, if there be any, of the preliminary test of the trained group can not be mistaken for transfer, since on the average this practice will be the same for the two groups. In a similar way the two-group method eliminates the possible confusion of transfer and maturation effects. Manifestly, on the average the two groups will mature equally. Psychologists who are familiar with the Binet tests can show us in children mental growth of two or even three years during one year of physical maturation. If experiments are performed with children as subjects, there is always this factor of maturation involved, especially when several months are allowed to pass between the preliminary and the final tests.

There is possibly another factor that the two-group method checks off, namely, the incubation tendency; that is, the tendency for a function to improve in efficiency during a period of disuse. This tendency is best illustrated by Swift's ball-tossing experiment. He had five adult subjects work at "keeping two balls going [in the air] with one hand, receiving and throwing one while the other is in the air . . . The balls used were of solid rubber and weighed 122.6 and 130.2 grams . . . . . Their diameters were 42 and 44 mm., respectively . . . . . The daily program consisted of ten trials, the subject in each case continuing the throwing until he failed to catch one or both of the balls."[10] Summarizing the results of two of the subjects who took the trouble to test the incubation tendency, Thorndike writes, "Subject H, having begun with a score of about 4, and having reached, in the last six

[10] Swift, E. J., Studies in the Psychology and Physiology of Learning, *Am. Jour. Psych.*, Vol. 14, p. 201.

days of forty-two days of practice, average scores of 50, 82, 92, 88, 68 and 105, was retested every thirty days for five months, and attained average scores of 70, 80, 140, 110, and 120. Being then tested after four hundred and eighty-one days, he attained an average score of 119. Being then tested after over four years, he attained an average score of 5; on the following day, one of 10; and on the successive following days, average scores of 18, 20, 26, 35, 66, 60, 45, 100 and 160. Subject E, having begun with a score of about 10, and having reached, in the last six days of fourteen days of practice, average scores of 31, 53, 80, 105, 115 and 127, was retested every thirty days for five months,[11] and attained average scores of 115, 145, 155, 230 and 325. Being next tested after an interval of 463 days, he attained an average score of 152."[12] It is possibly true that "the disuse of a mental function weakens it, and the amount of weakening increases, the longer the lack of exercise,"[13] but at the time while the learning remains fresh, as is the case with the two subjects cited above who showed a decided improvement in their five months' re-test, the incubation tendency was still going on. Usually an experiment of this kind does not last more than a few months. But if the incubation tendency is involved the two-group method eliminates it.

It is clear that the two-group method has been a great help in experiments of this kind. Though the intention has been to check off the influence due to the preliminary test, it eventually eliminates the influence of maturation as well as the incubation tendency.

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[11] "There was some practice with the left hand during the first thirty days interval in the case of both H and E."

[12] Thorndike, E. L., *Educational Psychology*, Vol. II, pp. 309–310.

[13] *Ibid.*, p. 300.

### *Three-Group Method*

While carrying on the present experiment the writer has found it expedient to make use of an additional group. The object of this was to determine the amount of difference due to changed conditions of the weather, from winter to spring; of the experimentation room, from the basement to the first floor; and of the daily program of studies (all the subjects had been promoted in their grades at the time of the final test). If an experiment is carried on for months, as was the present one, a change of weather and of the daily program of studies can not be helped. These changes may prove to be more or less favorable to the final test, and hence both the trained and the untrained groups may test out better or worse than under the conditions of the preliminary test. A third group, taking neither training nor the preliminary test, but simply the final test together with the other two groups, will show just how much difference there is at the final test, and whether the trained and the untrained groups have improved or deteriorated. In case the third group yields a better result than did the two other groups at their preliminary test, it will indicate that the conditions of the final test are more favorable; if a worse result, that the conditions at the final test are less favorable; and if the same result, that will confirm whatever difference there may be between the trained and the untrained groups.

The three-group method will prove useful for another reason. When poetry and prose are used to test memory, or when arithmetical problems are used to test reasoning, or when the marking of letters and figures are used to test discrimination, it is almost im-

possible to find materials of equal difficulty for both the preliminary and the final tests. Consequently, there have been in the past experiments, cases where both trained and untrained groups have shown improvements and other cases where both have shown a retrogression on account of the material chosen for the final test. If the material for the final test has been easier than that used in the preliminary, both trained and untrained groups have shown improvement and if the material chosen for the final test has been more difficult, both groups have shown a decrease in efficiency. Just how much easier or more difficult the material chosen for the final test has been than that of the preliminary, a third group would have shown. For these reasons the writer believes that future experimenters may find the additional group helpful.

## NEW EXPERIMENTAL DATA

### Experiment 1

*Aim*

As has been stated in the introduction, since there is yet considerable disagreement as to the means, extent and amount that a specifically trained function may affect other functions, it became the purpose of this study to throw some light on these various points by using new data.

A word should be added to show why sense discrimination was chosen for experiment. It was thought that work with sense discrimination can be made very simple; that it is easy, too, for use with the children. Moreover, through the influence of Montessori there has been of late somewhat of a revival of interest in sense training. Her visit to America in 1913 aroused much interest, and her book, *The Montessori Method*, has gone through several editions. Her explanation of her theory will prove enlightening: "We cannot create observers by saying 'observe,' but by giving them the power and the means for this observation, and these means are procured through education of the senses. Once we have aroused such activity, auto-education is assured, for refined, well-trained senses lead us to a closer observation of the environment, and this, with its infinite variety, attracts the attention and continues the psychosensory education."[14]

Since our experiment includes a few tests on forms, it will be of interest to cite her opinion on this matter

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[14] Montessori, M., *The Montessori Method*, p. 228.

also. She says: "He [the child] will, however, see the plane geometric forms perfectly represented in the windows and doors, and in the faces of many solid objects in use at home. Thus the knowledge of the forms given him in plane geometric insets will be for him a species of magic *key*, opening the external world, and making him feel that he knows its secrets."[15]

Montessori does not make clear how many doors of the external world this magic key opens, nor how wide, nor just in what way they are opened. If it is true that well trained senses will invariably lead children to closer observation, it will probably mean great changes in the daily program of the elementary schools. It is but just that educational reforms, discoveries, or any new movements should be recognized and promoted, once they are found to be worthy. On the other hand, if they are not confirmed by properly controlled tests, students of education owe it to the public to expose their fallacy. This explains the purpose of using sense training in our experiment.

### *Subjects*

When the work was started in October, 1913, twenty-two children took the preliminary test, and eleven of these were retained for the training. Experiments were conducted only on the days when there was school. These twenty-two children represented approximately four grades of mentality, according to the teachers' opinions and the Binet tests taken in two successive years, 1911 and 1912. It was thought that possibly bright children might be benefited more than dull ones by a special training and thus would

[15] Montessori, M., *Ibid.*, p. 239.

show a larger amount of transfer, so pupils of four different grades of mentality (excellent, good, average and poor) were chosen to test this possibility. Unfortunately, the two lower grades (average and poor) were unable to continue in the experiment to the end because the experimental work was thought to interfere with their school work. Those who were left, therefore, rank above the average pupils of their age.

TABLE 1

*Number of Subjects, their Age in Jan., 1914, their School Grades, the Teachers' Estimate of their School Work, and their Mental Growth from 1911 to 1912 according to the Binet Tests*[16]

TRAINED GROUP

| Subjects | Age in Jan., 1914 | Grade in 1914 | Teachers' estimate | Mental growth 1911–1912 |
|---|---|---|---|---|
| I | 9.1 | 4 B | Excellent | 1.2 |
| II | 9.4 | 3 B | Good | |
| III | 11.1 | 4 B | " | .8 |
| IV | 10.0 | 3 A | " | 1.6 |
| V | 12.7 | 5 B | " | 1.4 |
| VI | 9.3 | 3 A | " | 1.0 |
| VII | 11.3 | 4 A | " | .4 |
| Average | 10.4 | | | 1.07 |

UNTRAINED GROUP

| Subjects | Age in Jan., 1914 | Grade in 1914 | Teachers' estimate | Mental growth 1911–1912 |
|---|---|---|---|---|
| VIII | 9.5 | 4 B | Excellent | .6 |
| IX | 9.9 | 4 A | Good | 1.2 |
| X | 10.3 | 3 A | " | 1.0 |
| XI | 9.4 | 4 A | " | 1.4 |
| XII | 11.3 | 3 A | " | .4 |
| XIII | 9.4 | 4 B | " | 1.2 |
| Average | 9.97 | | | .97 |

On account of the dropping out of the less gifted children (four out of the trained group and five out

[16] After C. S. Berry, University of Michigan. Unpublished study.

of the untrained group) the balance of these two groups is slightly in favor of the trained group, especially in age and rate of mental growth. The difference is, however, not large enough to make the two groups non-comparable.

### *The Trained Function*

The trained function was the discrimination of different lengths of vertical lines drawn on cards. There were eleven of these cards, each $3 \times 6\frac{1}{2}$ inches. On each card only one line was drawn, always in the center and parallel to the short side. The longest line, on the card *a*, was $1\frac{2}{3}$ inches, $\frac{1}{30}$ of an inch longer than the next line on card *b*. The line on card *b* was $\frac{1}{30}$ of an inch longer than the line on card *c*, and so on to card *k*, which had a line of $1\frac{1}{3}$ inches. All lines were drawn of a uniform width of .2 mm.

Figure 1 shows the apparatus used in training. The table A–B, 36 inches long, 24 inches wide and 25 inches high, was enclosed during the experiment by a square topped canopy as large as the table itself. This canopy was made $2\frac{1}{2}$ feet above the table, and supported by a light wooden framework nailed to the edges of the table. In order to get the photograph, the framework and canopy were both removed. The subject sat in chair C at the end of the table and the operator in chair D at the side of the table to his left. Two cards were shown to the subject in succession, and the subject gave his judgment in terms of the second card shown saying "longer" or "shorter" (than the line on the first card). The first card, 1 in Figure 1, was exposed to the subject for three seconds, the operator counting to himself 1-2-3, and then by a pull on the string (6), card 1 was pulled out of sight of the

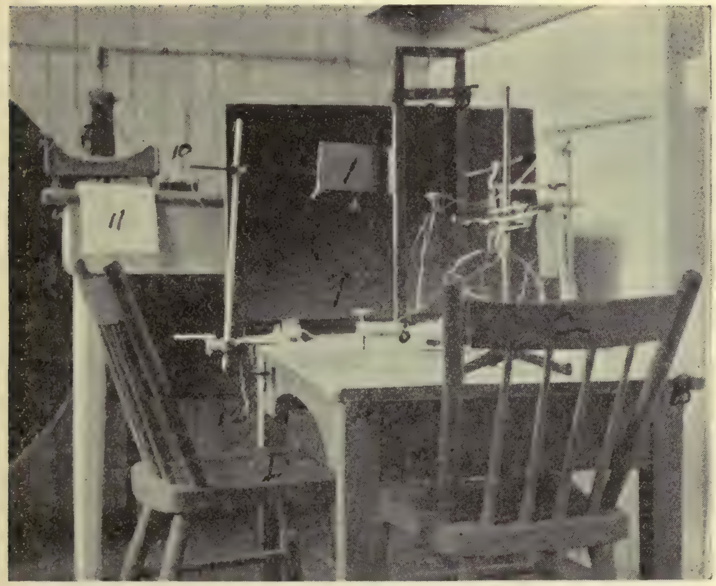



FIGURE 1

AB Table for experiment
C Chair of subject
D Chair of operator
1 First card shown
2 Second card shown
4 Cover for card last shown
5 Cattell Fall.
6 String that pulls card 1 out of sight as cover 4 comes down, thus showing card 2
7 Lip-key
8 Bergström Chronoscope
10 Electric commutator
11 Paper for record
12 String to let fall cover 4

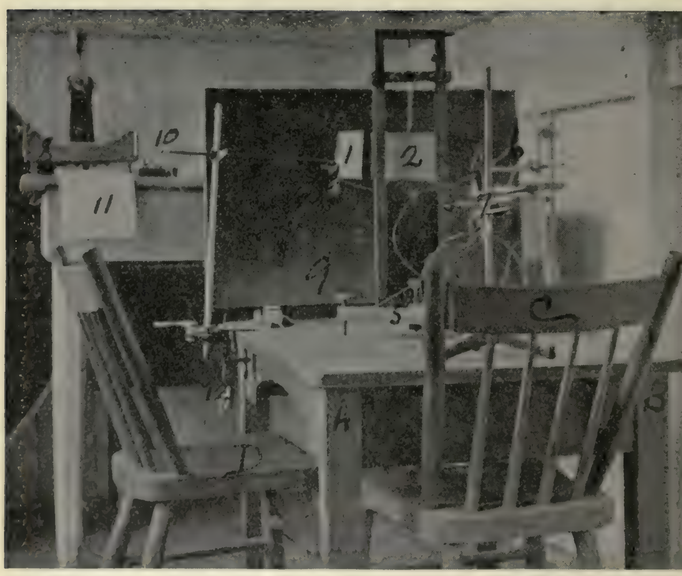



FIGURE 2

subject and card 2 appeared (see Figure 2). It will be noticed that card 2, now in view, was hidden behind the falling plate (4) of the Cattell Fall (5) while card 1 was first shown. The falling of the plate (4) showed card 2 and, at the same time, pulled card 1 out of sight by means of a string (6). While looking at these cards, the subject took hold of the lip-key (7) with his teeth. The lip-key was connected with the Cattell Fall (5) and the Bergström Chronoscope (8) with electric wires. As soon as the plate (4) came down, that is, as soon as the second card was shown, the chronoscope was automatically set going, and was stopped again whenever the subject released the lip-key in giving his judgment. Thus, the time spent by the subject in judging whether the second line was longer or shorter than the first was recorded by the chronoscope. To be sure that a uniform amount of light was thrown upon the cards, two tungsten lights, 40 watts each, were hung inside the canopy, six inches from the top and eight inches from the end of the table where the subject sat. A large cardboard, tied close to the lights, kept the lights from shining into the eyes of the subject. The light from outside was entirely excluded. The lip-key was always placed six inches from the edge of the table and the Cattell Fall two feet from this.

The difference between the two lines shown for judgment was invariably 1/30 of an inch. Each day a subject made twenty judgments, there being ten cases where the second line was shorter and ten cases where the second line was longer. The order of the different pairs to be judged was changed every day by the shuffling of a set of slips on which the different pairs were written. The following is a sample training record.

TABLE 2

*Sample of a Record During the Training*

Feb. 4, 8:30 A. M., Subject I

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Card e compared with card d | | 1230 sigmas | | Judgment wrong | |
| 2. | " h " " " g | | 1270 | " | " | right |
| 3. | " c " " " d | | 720 | " | " | " |
| 4. | " g " " " f | | 930 | " | " | " |
| 5. | " b " " " c | | 635 | " | " | " |
| 6. | " g " " " h | | 2000 | " | " | wrong |
| 7. | " i " " " h | | 910 | " | " | right |
| 8. | " f " " " g | | 1280 | " | " | " |
| 9. | " d " " " e | | 665 | " | " | " |
| 10. | " i " " " j | | 1200 | " | " | " |
| 11. | " f " " " e | | 1000 | " | " | " |
| 12. | " k " " " j | | 870 | " | " | " |
| 13. | " d " " " c | | 1000 | " | " | " |
| 14. | " j " " " k | | 1300 | " | " | " |
| 15. | " j " " " i | | 945 | " | " | " |
| 16. | " b " " " a | | 570 | " | " | wrong |
| 17. | " h " " " i | | 840 | " | " | right |
| 18. | " c " " " b | | 1370 | " | " | " |
| 19. | " a " " " b | | 770 | " | " | " |
| 20. | " e " " " f | | 1170 | " | " | " |
| | | Total | 20675 | " | " | 3 wrong |
| | | Net | 1034 | " | " | 17 right |
| | Average time for wrong judgments | | 1267 | " | | |
| | " " " right " | | 993 | " | | |

After each judgment, the subject was immediately told whether he was right or wrong. This was done to show him where his mistakes were, that he might make correction.

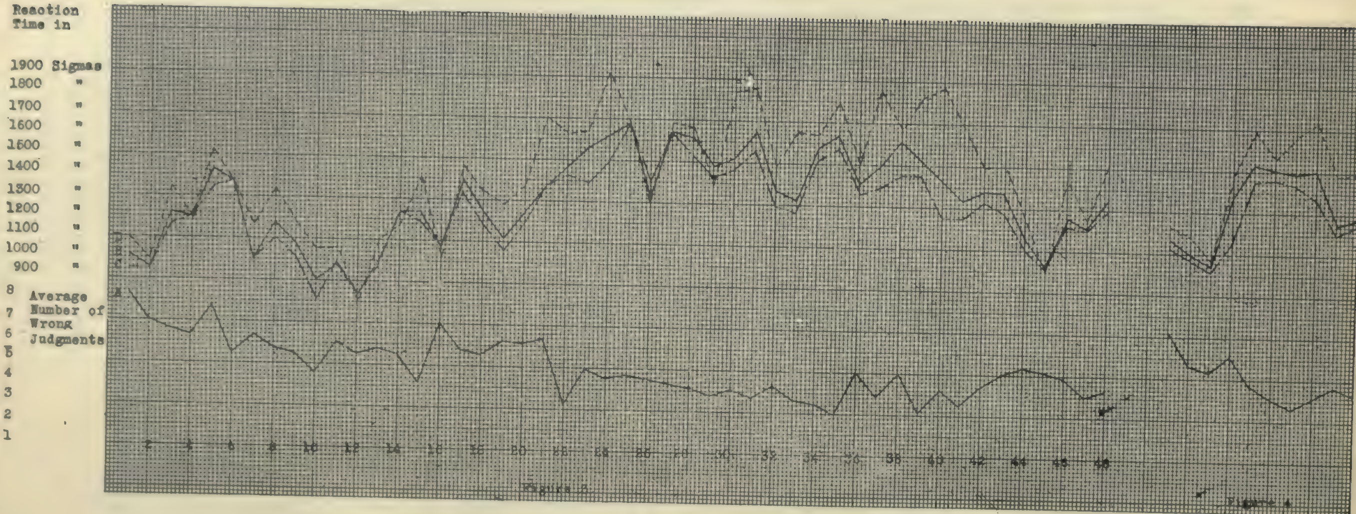
## *Results of Training*

Table 3 and Figure 3 give the results of the trained group. Between February 26 and March 19 the work was discontinued on account of a misunderstanding of the nature of the experiment by some of the parents whose children acted as subjects. Spring vacation, April 4 to 14, was the cause of another discontinuation. Counting out these periods of dis-

continuations and week-ends when there was no school, together with a few holidays, there were given altogether forty-eight trainings, covering a space of fourteen weeks.

If columns 3 and 6 in Table 3 and curves A and B in Figure 3 are compared, it will be noticed that, while the number of wrong judgments decreased from day to day, there was, correspondingly, an increased reaction time (time used by the subjects, when the line on the second card was shown, to judge whether that was longer or shorter than the first). In other words, the accuracy in judging vertical lines ranging from 1⅓ to 1⅔ inches with a constant difference of 1/30 of an inch seems to depend upon the amount of time used for each judgment. This increased time was rather unexpected, because in past experiments, in memorizing poetry, or in reasoning out puzzles, training had resulted in a decrease of time. This temporal difference suggests that sensory and higher mental improvements are brought about in different ways. It may be that while higher mental improvements can be attained by many short-cut methods, there is only one way for sensory improvement, that is, by a better adaptation of the sense organ, which means taking more time.

If columns 4 and 5 and curves C and D are compared, it will be noticed that in most cases more time was used on the wrong than on the right judgments. This means that, when the subjects were confronted with difficult cases to judge, they usually made use of more time to resolve the difficulty. However, there were cases when they could not judge rightly in spite of the increased time used, hence the average reaction time for wrong judgments is considerably higher than that of the right judgments. When subjects, after




FIGURES 3 AND 4

THE COURSE OF IMPROVEMENT DUE TO PRACTICE

Curve A, the average number of wrong judgments
Curve B, the average reaction time of 20 judgments
Curve C, the average reaction time for wrong judgments only
Curve D, the average reaction time for right judgments only

TABLE 3

*Average Reaction Time of Seven Subjects, Twenty Judgments Daily; Average Reaction Time for the Right and Wrong Judgments; and the Average Number of Wrong Judgments. Time in Sigmas*

| No. of training | Date | Average reaction time, 20 judgments altogether | Average reaction time, wrong judgments | Average reaction time, right judgments | Average No. of wrong judgments |
|---|---|---|---|---|---|
| 1 | Jan. 7 | 1014 | 1104 | 946 | 8.50 |
| 2 | " 8 | 951 | 983 | 950 | 7.00 |
| 3 | " 9 | 1212 | 1339 | 1170 | 6.86 |
| 4 | " 12 | 1198 | 1194 | 1202 | 6.29 |
| 5 | " 13 | 1434 | 1517 | 1343 | 7.67 |
| 6 | " 14 | 1371 | 1373 | 1375 | 5.57 |
| 7 | " 15 | 991 | 1005 | 991 | 6.25 |
| 8 | " 16 | 1172 | 1328 | 1103 | 5.86 |
| 9 | " 19 | 1070 | 1186 | 1013 | 5.50 |
| 10 | " 20 | 890 | 1040 | 805 | 4.50 |
| 11 | " 21 | 963 | 1047 | 980 | 6.00 |
| 12 | " 22 | 813 | 803 | 821 | 5.50 |
| 13 | " 23 | 1003 | 1090 | 972 | 5.67 |
| 14 | " 27 | 1219 | 1177 | 1219 | 5.57 |
| 15 | " 28 | 1236 | 1409 | 1191 | 4.14 |
| 16 | " 29 | 1055 | 988 | 1072 | 7.00 |
| 17 | " 30 | 1384 | 1460 | 1344 | 5.75 |
| 18 | Feb. 3 | 1222 | 1326 | 1168 | 5.57 |
| 19 | " 4 | 1102 | 1277 | 1062 | 6.17 |
| 20 | " 5 | 1238 | 1364 | 1184 | 6.14 |
| 21 | " 6 | 1361 | 1684 | 1362 | 6.33 |
| 22 | " 9 | 1451 | 1618 | 1433 | 3.14 |
| 23 | " 10 | 1553 | 1624 | 1387 | 4.86 |
| 24 | " 11 | 1606 | 1936 | 1487 | 4.43 |
| 25 | " 12 | 1672 | 1581 | 1684 | 4.57 |
| 26 | " 13 | 1308 | 1270 | 1285 | 4.43 |
| 27 | " 16 | 1636 | 1690 | 1637 | 4.29 |
| 28 | " 17 | 1612 | 1656 | 1534 | 4.14 |
| 29 | " 18 | 1471 | 1371 | 1436 | 3.71 |
| 30 | " 19 | 1506 | 1830 | 1485 | 4.00 |
| 31 | " 20 | 1627 | 1845 | 1554 | 3.71 |
| 32 | " 24 | 1347 | 1480 | 1285 | 4.33 |
| 33 | " 25 | 1314 | 1642 | 1277 | 3.60 |
| 34 | Mar. 19 | 1576 | 1624 | 1530 | 3.50 |
| 35 | " 20 | 1622 | 1804 | 1565 | 3.00 |
| 36 | " 23 | 1389 | 1515 | 1349 | 5.00 |
| 37 | " 24 | 1486 | 1842 | 1392 | 3.83 |
| 38 | " 25 | 1606 | 1661 | 1447 | 5.00 |
| 39 | " 26 | 1509 | 1812 | 1449 | 3.17 |
| 40 | " 27 | 1449 | 1868 | 1256 | 4.20 |
| 41 | " 30 | 1331 | 1703 | 1255 | 3.57 |
| 42 | " 31 | 1369 | 1491 | 1335 | 4.43 |
| 43 | Apr. 1 | 1374 | 1500 | 1291 | 5.00 |
| 44 | " 2 | 1163 | 1228 | 1116 | 5.33 |
| 45 | " 3 | 1020 | 993 | 1017 | 5.17 |
| 46 | " 14 | 1257 | 1433 | 1230 | 4.83 |
| 47 | " 15 | 1212 | 1224 | 1204 | 4.00 |
| 48 | " 16 | 1332 | 1507 | 1310 | 4.33 |
| Total | | 62697 | 68342 | 60503 | 241.41 |
| Aver. | | 1306 | 1424 | 1260 | 5.03 |

giving a long reaction time of three or four seconds, were asked why it took them so long to give that judgment, they usually answered: "I wanted to have a good look at it [the second card]"; "I can tell better if I look at it longer"; or "I know that one is wrong, because I did not see it long enough." These answers also indicate that long reaction times were spent for purposes of visual adjustment or adaptation.

Table 4 and Figure 4 show the same thing as Table 3 and Figure 3, only in an abridged way. Instead of the average daily training record, the average records of every five training days are taken. These charts show more clearly how decrease of wrong judgments is accompanied by increase of reaction time.

TABLE 4

*Average Reaction Time and Number of Wrong Judgments in every Five Days, Derived from Table 3*

| No. of Trainings | Date | Aver. reaction time of 100 judgments | Aver. reaction time of wrong judgments | Aver. reaction time of right judgments | Aver. number of wrong judgments |
|---|---|---|---|---|---|
| 1 to 6 | Jan. 7 14 | 1162 | 1228 | 1122 | 7.26 |
| 6 " 11 | " 14–21 | 1099 | 1186 | 1058 | 5.54 |
| 11 " 16 | " 21–29 | 1047 | 1105 | 1037 | 5.38 |
| 16 " 21 | " 29 Feb. 6 | 1200 | 1283 | 1166 | 6.13 |
| 21 " 26 | Feb. 6-13 | 1529 | 1689 | 1471 | 4.67 |
| 26 " 31 | " 13 20 | 1507 | 1564 | 1476 | 4.12 |
| 31 " 36 | " 20 Mar. 23 | 1497 | 1679 | 1442 | 3.63 |
| 36 " 41 | Mar. 23 30 | 1488 | 1740 | 1379 | 4.24 |
| 41 " 46 | " 30 Apr. 14 | 1252 | 1383 | 1203 | 4.70 |
| 46 " 49 | Apr. 14 17 | 1267 | 1388 | 1248 | 4.39 |

The curves show four phases or periods. From the first to the fourteenth training the subjects found it possible to reduce wrong judgments and also the re-

action time—fast improvement at the beginning, following the general law of learning; from the fourteenth to the thirty-fourth training the subjects discovered that, in order to reduce further the number of wrong judgments, it was necessary to lengthen their reaction time; and from the thirty-fourth training to the forty-sixth the reaction times have decreased conjointly with an increase of the number of wrong judgments. This third period was a time of discouragement. Some of the children were withdrawn on the ground that they were not well up with the class in their studies. After a delay of three weeks a readjustment was made and the experiment continued with seven subjects. That these subjects did not do their best work is probable from the increased number of wrong judgments and the decreased reaction time. Spring vacation from April 4 to 14 caused another interruption in the experiment. The last period, from the 14th to the 17th of April, was covered with the understanding by the subjects that these trainings would be the last ones. The decrease of the number of wrong judgments and the increase of reaction time is very noticeable.

In the curves the reader will find places where increased reaction times do not correspond to decrease of wrong judgments. This can be explained by the fact that the reactions of the different subjects were not the same; some of them took two or three times as long as did others to give a judgment. The absence of a subject whose reaction time was longer than the others would have brought the curve of averages lower than normal while the absence of a subject whose reaction time was shorter than the others would have made the curve run higher than

normal. The same individual differences were shown in the number of wrong judgments. Some subjects have four or five times as many wrong judgments as do others. The absences caused some irregularity. As a whole, it is shown clearly that decrease of wrong judgment is accompanied by increase of reaction time.

### *Summary of the Training Period*

1. With seven subjects, averaging $40\frac{1}{2}$ trainings each, and covering a period of over three months, the wrong judgments of vertical lines that ranged between $1\frac{2}{3}$ and $1\frac{1}{3}$ inches by a constant difference of $\frac{1}{30}$ of an inch, decreased 40.01 per cent, accompanied by an increased reaction time of 14.70 per cent.

2. The decrease of wrong judgments seems to have been brought about by the increased reaction time, (1) because the decrease in number of wrong judgments went hand in hand with a longer reaction time; and (2) because, according to the statements of the subjects, a longer reaction time was favorable to better visual adaptation.

3. Visual discrimination in children seems to improve very slowly.

### *The Tested Functions*

The functions tested were three—the discrimination of pitch, the discrimination of shades of color, and the discrimination of size. These functions were tested both before and after the training with line-lengths. For comparison, the results of the preliminary test taken before training, and the final test taken after training, are both treated here.

The experiment started with eleven subjects in each of the trained and the untrained groups. Only seven

TABLE 5

*Total Amount of Improvement as a Result of Visual Sense Training*

| Subject | Total No. trainings received | Average number of wrong judgments of first 3 trainings | Average reaction time of first 3 trainings | Average number of wrong judgments of last 3 trainings | Average reaction time of last 3 trainings | Decrease of average number of wrong judgments | Decrease of reaction time |
|---|---|---|---|---|---|---|---|
| I | 36 | 6.33 | 1512 sigmas | 0.00 | 1672 sigmas | 6.33 | —160 sigmas |
| II | 47 | 7.00 | 1049 " | 5.00 | 1736 " | 2.00 | —687 " |
| III | 39 | 9.00 | 783 " | 7.33 | 990 " | 1.67 | —207 " |
| IV | 45 | 7.66 | 1161 " | 5.66 | 1099 " | 2.00 | 62 " |
| V | 45 | 6.66 | 945 " | 6.00 | 1031 " | .66 | – 86 " |
| VI | 38 | 7.00 | 1005 " | 2.33 | 1240 " | 4.67 | – 235 " |
| VII | 33 | 4.66 | 1999 " | 2.66 | 1923 " | 2.00 | 76 " |
| Total | 283 | 48.31 | 8454 " | 28.98 | 9691 " | 19.33 | –1237 " |
| Average | 40.4 | | | | | | |
| Percentage of improvement | | | | | | 40.01 | –14.63 |

subjects in the trained group completed the training and only six of the untrained group were ready to take the final test. In the following tables the difference between the trained and the untrained groups, that is, the average amount of improvement of the seven trained subjects, minus the average amount of improvement of the six untrained subjects, is considered improvement due to training. Owing to the extended period the experiment covered, it was thought that the change of season from winter to spring, and the variation in the daily study program of the subjects might affect the success of the test. For this reason, as has been explained in the introduction, a control group of three was selected to take the test for the first time when the other two groups were taking their final test. It was thought that, if these changed conditions were more favorable, the control group would be more successful than the two other groups with their preliminary, and if the changed conditions were less favorable, the control group would be less successful. The three subjects forming the control group were all excellent pupils, ahead in their studies, and therefore could afford the time to take the test. Since they were the only available ones at the time, they were taken, notwithstanding their superiority.

### 1. *Discrimination of Pitch*

The preliminary part of this test was given on October 15, 16 and 17, 1913, the final part on April 17, 20 and 21, 1914, i. e., after an interval of five months. A pair of Koenig tuning forks, each of which possessed a vibration rate of 256 a second, was used. In order to vary the pitches by small steps a brass rider was made for one of the tuning forks, so as to be set at any place

on one arm of the fork by a set screw. As the rider moved little by little towards the resonance box the two tuning forks approached nearer and nearer in pitch; as it moved away from the resonance box the difference of the two tuning forks grew larger. A metric scale was used to set the rider, which was moved 5 millimeters at a time. The beats that the two tuning forks produced per minute, as the rider was moved from the end of the tuning fork toward the resonance box, were as shown in Table 6.

The 840, 655 and 575 beats were counted from tone-recorder records and the rest of them were counted accurately by a stop-watch.

TABLE 6

*Results from Testing the Forks Used for Pitch Discrimination*

| | Position of the Rider | Beats Per Minute |
|---|---|---|
| 1 | 0 mm. from end of the tuning fork | 840 beats |
| 2 | 5 " " " " " " " | 665 " |
| 3 | 10 " " " " " " " | 575 " |
| 4 | 15 " " " " " " " | 480 " |
| 5 | 20 " " " " " " " | 420 " |
| 6 | 25 " " " " " " " | 385 " |
| 7 | 30 " " " " " " " | 360 " |
| 8 | 35 " " " " " " " | 335 " |
| 9 | 40 " " " " " " " | 305 " |
| 10 | 45 " " " " " " " | 275 " |
| 11 | 50 " " " " " " " | 250 " |
| 12 | 55 " " " " " " " | 215 " |
| 13 | 60 " " " " " " " | 185 " |
| 14 | 65 " " " " " " " | 155 " |
| 15 | 70 " " " " " " " | 138 " |
| 16 | 75 " " " " " " " | 115 " |
| 17 | 80 " " " " " " " | 90 " |
| 18 | 85 " " " " " " " | 78 " |
| 19 | 90 " " " " " " " | 62 " |
| 20 | 95 " " " " " " " | 50 " |
| 21 | 100 " " " " " " " | 40 " |
| 22 | 105 " " " " " " " | 30 " |
| 23 | 110 " " " " " " " | 22 " |
| 24 | 115 " " " " " " " | 15 " |

In the actual tests of discrimination the rider was moved 24 times towards the resonance box from the end of the tuning fork and 24 times in the opposite direction, which brought it back again to the end of the fork. Five judgments were given for each move of the rider, making altogether 240 judgments.

To finish the 240 judgments three sittings were necessary. On the first day the subjects made 60 judgments, beginning with the larger differences from 1 to 13, Table 6; on the second day the subjects made another 60 judgments, beginning with difference 13 and ending with difference 24; and on the last day the process was reversed,—this time beginning with the smaller differences of the tuning forks and working towards larger differences, from 24 backwards to 1. The first two sittings took about twelve minutes each, the last sitting about twenty minutes. During the experiment the subjects sat at an average distance of ten feet from the tuning forks. On a desk in front of each subject was a pencil and a typewritten sheet on which was printed "A 1 2 3 4 5 B 1 2 3 4 5 C 1 2 3 4 5," etc., ending with the letter X. A, B, C, etc., are indicated in Table 6 by column one, 1, 2, 3, etc., 1 corresponding to A, 2 to B, and so on. The numerals after each letter indicated the places under which the judgments were to be written. All subjects were told to record their judgments with reference to the second fork struck; that is, if this sounded lower than the first fork, they were to write under the numeral an L; if it sounded higher, they were to write an H. To be sure that every subject knew what to do, a trial sheet was given to each on the first day of the preliminary test. The subjects were seated in alternate seats with their backs towards the tuning forks. Though

the lower fork was sounded last as often as was the higher, the order in which they followed each other was irregular. Thus the subjects were prevented from copying from one another, from anticipating which was the low-toned fork and from forming any association with the order in which the two forks were struck.

The forks were hung near the center of the room with the tines down, as is shown in Figure 5. Both resonance boxes in which the forks were set, were held by string loops about their ends. These four string loops were attached to a wooden bar which was itself hung from the ceiling. In this way, as the bar turned, the tuning forks exchanged places and hence there was no chance of the subjects associating lower or higher pitches with direction or distance. The forks were struck by a solid rubber-ball hammer; about three seconds after the first fork was struck, it was stopped with the hand and the second tuning fork was struck. The subjects immediately wrote down their judgments, L or H. While they were doing this, the operator made his preparation for the next trial, and then announced to the subjects under which letter and numeral their judgment should be written down. In front of the operator was a sheet of paper to guide him regarding the places of the rider and the order of the high or low pitches throughout the test. By constant announcement of the letters and numerals the subjects knew whether they were writing down their judgments at the proper places. These arrangements were followed in both the preliminary and the final tests.

The results of the test are shown in Tables 7A, 7B and 7C. On account of the absence of subject XIII, there were only five left in the untrained group.

FIGURE 5

The author has found that the auditory sense in children fatigues easily. The first two sittings took about 12 minutes each, and the last sitting took about 18 minutes, in both the preliminary and final tests. It will be noticed from Table 7A that, as the pitch of the two tuning forks decreased in difference, no subject escaped from making wrong judgments. This, not only because towards the end of the test the differences in pitch became smaller, but also because the subjects were getting fatigued. That this was the fact was brought out by the record of the second sitting. When the differences of the forks continued to decrease from the first, some of the subjects started in with no misjudgments, although midjudgments had already begun towards the last of the first sitting. Some of the subjects doubtless would not have made any wrong judgments, had it not been for fatigue. We can infer this from the fact that, as the process was reversed in the third sitting, subjects I, IV, XIV and XV made no wrong judgments. It is even probable that some of them can distinguish differences of less than 15 beats a minute, .4 vibration. Fatigue, in the third sitting, though it did not interfere with these subjects,. was a handicap for the rest. These other subjects continued their misjudgments beyond the point where their judgments were still right in the first two sittings. This raising of the threshold as the difference of the forks became larger and larger was doubtless due to fatigue.

In Table 7A it will be seen that both trained and untrained groups have lowered their thresholds—the place where the difference of the tuning forks was just distinguishable. However, the trained group gained 33.43 per cent more than the untrained as the tuning

TABLE 7

*A. Point at which Subjects began to Make Wrong Judgments, as Indicated by the Number of Beats per Minutes*

Trained Group

| | Preliminary Test | | Final Test | | Improvement | |
|---|---|---|---|---|---|---|
| Subjects | Decreasing | Increasing | Decreasing | Increasing | Decreasing | Increasing |
| I | 180 | 0 | 78 | 0 | 102 | 0 |
| II | 575 | 575 | 78 | 335 | 497 | 240 |
| III | 840 | 840 | 840 | 840 | 0 | 0 |
| IV | 360 | 0 | 62 | 420 | 298 | —420 |
| V | 60 | 480 | 155 | 250 | —95 | 230 |
| VI | 385 | 385 | 90 | 50 | 295. | 335 |
| VII | 840 | 385 | 385 | 360 | 455 | 25 |
| Total | 3240 | 2665 | 1688 | 2255 | 1552 | 410 |
| Per cent | | | | | 47.90 | 15.38 |
| Average | 463 | 381 | 241 | 322 | | |

Untrained Group

| | | | | | | |
|---|---|---|---|---|---|---|
| VIII | 665 | 840 | 575 | 585 | 90 | 225 |
| IX | 840 | 840 | 840 | 840 | 0 | 0 |
| X | 15 | 785 | 335 | 305 | —320 | 480 |
| IX | 840 | 840 | 305 | 360 | 535 | 480 |
| XII | 335 | 385 | 250 | 250 | 85 | 135 |
| Total | 2695 | 3690 | 2305 | 2340 | 390 | 1350 |
| Per cent | | | | | 14.47 | 36.58 |
| Average | 539 | 738 | 461 | 468 | | |
| Per cent of Transfer | | | | | 33.43 | —21.20 |

Control Group

| | | | | | | |
|---|---|---|---|---|---|---|
| XIV | | | 22 | 0 | | |
| XV | | | 250 | 0 | | |
| XVI | | | 115 | 50 | | |
| Total | | | 387 | 50 | | |
| Average | | | 129 | 17 | | |

TABLE 7

*B. Number of Wrong Judgments Made by Subjects*

Trained Group

| Subjects | Preliminary Test: Low fork struck last | Preliminary Test: High fork struck last | Final Test: Low fork struck last | Final Test: High fork struck last | Improvement: Low fork struck last | Improvement: High fork struck last |
|---|---|---|---|---|---|---|
| I | 6 | 4 | 3 | 2 | 3 | 2 |
| II | 32 | 26 | 15 | 3 | 17 | 23 |
| III | 63 | 66 | 54 | 59 | 9 | 7 |
| IV | 7 | 4 | 9 | 18 | —2 | —14 |
| V | 2 | 2 | 1 | 8 | 1 | – 6 |
| VI | 8 | 10 | 6 | 10 | 2 | 0 |
| VII | 44 | 22 | 21 | 40 | 23 | —18 |
| Total | 162 | 134 | 109 | 140 | 53 | —6 |
| Per cent | | | | | 32.72 | —4.48 |
| Average | 23 | 19 | 16 | 20 | | |

Untrained Group

| Subjects | Preliminary Test: Low fork struck last | Preliminary Test: High fork struck last | Final Test: Low fork struck last | Final Test: High fork struck last | Improvement: Low fork struck last | Improvement: High fork struck last |
|---|---|---|---|---|---|---|
| VIII | 38 | 35 | 39 | 14 | —1 | 21 |
| IX | 91 | 17 | 35 | 42 | 56 | —25 |
| X | 11 | 12 | 24 | 13 | —13 | —1 |
| XI | 60 | 40 | 30 | 29 | 30 | 11 |
| XII | 6 | 13 | 8 | 17 | —2 | – 4 |
| Total | 206 | 117 | 136 | 115 | 70 | 2 |
| Per cent | | | | | 33.98 | 1.71 |
| Average | 41 | 23 | 27 | 23 | | |
| Per cent of Transfer | | | | | —1.26 | —6.19 |

Control Group

| Subjects | Preliminary Test: Low fork struck last | Preliminary Test: High fork struck last | Final Test: Low fork struck last | Final Test: High fork struck last | Improvement: Low fork struck last | Improvement: High fork struck last |
|---|---|---|---|---|---|---|
| XIV | | | 5 | 3 | | |
| XV | | | 4 | 5 | | |
| XVI | | | 8 | 3 | | |
| Total | | | 17 | 11 | | |
| Average | | | 6 | 4 | | |

TABLE 7

*C. Total Percentage of Successes Made by the Subjects, 240 Trials Taken as the Basis*

Trained Group

| Subjects | Preliminary Test 1 | Preliminary Test 2 | Final Test 3 | Final Test 4 | Improvement 5 | Improvement 6 |
|---|---|---|---|---|---|---|
| I | 97.50 | 98.33 | 98.75 | 99.17 | 1.25 | .84 |
| II | 86.67 | 89.17 | 93.75 | 98.75 | 7.08 | 9.58 |
| III | 73.75 | 72.50 | 77.50 | 75.42 | 3.75 | 2.92 |
| IV | 97.08 | 98.33 | 96.25 | 92.50 | —.83 | —5.83 |
| V | 99.17 | 99.17 | 99.58 | 96.67 | .41 | —2.50 |
| VI | 96.67 | 95.83 | 97.50 | 95.83 | .83 | 0 |
| VII | 81.67 | 90.83 | 91.25 | 83.33 | 9.58 | —7.50 |
| Total | 632.51 | 644.16 | 654.58 | 641.67 | 22.07 | —2.49 |
| Average | | | | | 3.15 | —.36 |

Untrained Group

| Subjects | Preliminary Test 1 | Preliminary Test 2 | Final Test 3 | Final Test 4 | Improvement 5 | Improvement 6 |
|---|---|---|---|---|---|---|
| VIII | 84.17 | 85.42 | 83.75 | 94.17 | —.42 | 8.75 |
| IX | 62.08 | 92.92 | 85.42 | 92.50 | 23.34 | —10.42 |
| X | 95.42 | 95.00 | 90.00 | 94.58 | –5.42 | –.42 |
| XI | 75.00 | 83.33 | 87.50 | 87.92 | 12.50 | 4.59 |
| XII | 97.50 | 94.58 | 96.67 | 92.92 | —.83 | —1.66 |
| Total | 414.17 | 451.25 | 443.34 | 452.09 | 29.17 | .84 |
| Average | | | | | 5.83 | .17 |
| Transfer | | | | | —2.68 | —.53 |

Columns 1, 3 and 5 indicate percentage of success when the low tuning fork was struck last.

Columns 2, 4 and 6 indicate percentage of success when the high tuning fork was struck last.

forks decreased in difference and showed a comparative loss of 21.20 per cent as they increased in difference. So far as the lowering of the threshold is concerned, the result shows a greater improvement in the trained group. This finding seems to be in accord with a previous experiment performed by Bennett,

who trained sixteen children of eleven years of age "in discriminating different saturations of blue" and tested them in their "other sense powers in discriminating different mixtures of (1) red and white, (2) yellow and green, (3) orange and black." The training lasted five months with two half-hour periods each week. "There was also a preliminary test in distinguishing pitches." In this last test the Gilbert tone-tester was employed. "F sharp was taken as the norm, and the method employed, that of minimal gradations. As the figures (See Table 10) present it, the sharpness went from a range of 4.4 points at the first test—each point representing an eighth of the distance from F to F sharp, or F sharp to G—to one of 3.5 at the last test with the boys, or a gain of 20%; and from 5.3 points to 4.1 points for the girls, or a gain of about 23%."[17] This large gain may be accounted for by the want of a control group of untrained subjects. In the present experiment the trained group made an even greater gain, 47.90 per cent in the upper threshold, as the difference in pitch decreased, and 15.38 per cent in the lower threshold, as the difference in pitch increased. But even such a large gain as this becomes practically insignificant when it is compared with the gain of the untrained group. It seems unjustifiable to conclude from such results that training is general.

Another experiment of a similar nature was performed by Coover and Angell. "Four reagents were trained in discrimination of intensities of *sound* for 17 days during an interval of 57 days. Each reagent made 40 judgments in each day's training. Before and after training the reagents were tested in the discrimination of shades of gray, each test consisting of three series,

[17] Bennett, C. J. C., *Formal Discipline*, p. 62.

each containing 35 judgments, delivered on 3 separate days."[18] Their three subjects made 4, 6, and 0 points of improvement, respectively. Judging from the number of judgments given to the reagents, the percentage of gain can not be very large. And they end their report by saying: "Our conclusion from the experiment, therefore, is that efficiency of sensible discrimination acquired by training with sound stimuli has been transferred to the efficiency of discriminating brightness stimuli, and that the factors in this transfer are due in great part to habituation and to a more economic adaptation of attention, *i. e.*, are general, rather than special in character."[19] There is possible no direct comparison between the present experiment and that of Coover and Angell, who used adults as subjects, trained them in auditory, and tested them in visual sensitivity, whereas the writer used children, trained them in visual and tested them in auditory sensitivity.

In reference to the number of wrong judgments presented in Table 7B, the decreases of the trained group were so small, no matter which is taken for the basis of calculation—the number of wrong judgments (Table 7B) or the total amount of success (Table 7C)—that it is doubtful whether they are really of importance. Mere chance might have caused that much difference. The control group is useless for purposes of comparison, because of the superior ability of the subjects.

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[18] Coover, J. E., and Angell, F., General Practice Effect of Special Exercise, *Am. Jour. Psych.*, Vol. 18., p. 331.

[19] *Ibid.*, p. 334.

*Summary for Pitch Discrimination*

1. In auditory discrimination children show signs of fatigue very quickly. Probably 12 minutes is too long a sitting for an average child of about ten.

2. There is no positive evidence from our experiment that efficiency in visual discrimination is transferred to efficiency in auditory discrimination.

*2. Discrimination of Shades of Color*

It seemed impossible to dye any paper with gradual saturations of color and keep these shades permanent, so shades of color in solution were used instead. Potassium bichromate, 20% $H_2SO_4$ + 20% $K_2Cr_2O_7$, which gives a beautiful orange color, fitted the purpose very well, and test tubes of a uniform size (¾ inch) were used. After they had been carefully washed and chemically cleaned, each tube was filled with 15 cubic centimeters of water. Various numbers of drops of the potassium bichromate were put into these test tubes by means of a pipette. Then they were sealed by melting the open end, and labeled.

This test was divided into two sittings of 17 judgments each, making altogether 34 trials. The following shows the order of the different comparisons during the two sittings.

In giving this test the writer used the same apparatus and method of procedure that were employed in the training. Figures 6 and 7 show the general arrangement.

Test-tube 1 (see Figure 6) was shown first for three seconds and then, by a pull on the string (12), the plate (4) in the Cattell Fall (5) was dropped, exposing test-tube 2 (see Figure 7) and covering test-tube 1 by

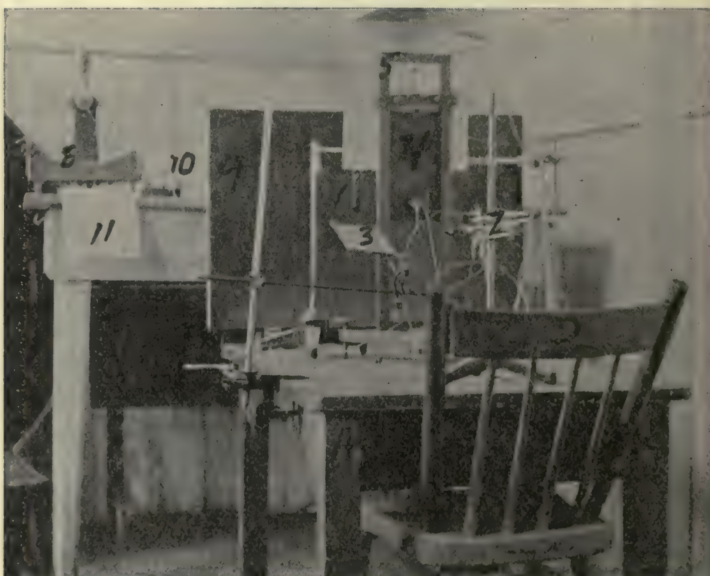


FIGURE 6

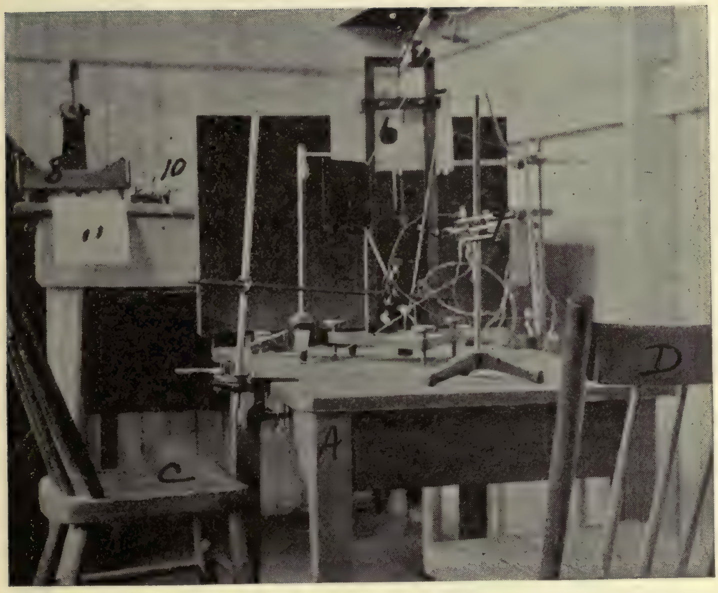


FIGURE 7

### First Sitting

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Test-tube | with | 11 | drops | of | solution | shown | first, | then | test-tube | with | 14 | drops |
| 2. | “ | “ | 1½ | “ | “ | “ | “ | “ | “ | “ | “ | 1½ | “ |
| 3. | “ | “ | 39 | “ | “ | “ | “ | “ | “ | “ | “ | 45 | “ |
| 4. | “ | “ | 24 | “ | “ | “ | “ | “ | “ | “ | “ | 28 | “ |
| 5 | “ | “ | 70 | “ | “ | “ | “ | “ | “ | “ | “ | 60 | “ |
| 6. | “ | “ | 33 | “ | “ | “ | “ | “ | “ | “ | “ | 28 | “ |
| 7. | “ | “ | 5 | “ | “ | “ | “ | “ | “ | “ | “ | 8 | “ |
| 8. | “ | “ | 45 | “ | “ | “ | “ | “ | “ | “ | “ | 55 | “ |
| 9. | “ | “ | 2½ | “ | “ | “ | “ | “ | “ | “ | “ | 3½ | “ |
| 10. | “ | “ | 14 | “ | “ | “ | “ | “ | “ | “ | “ | 11 | “ |
| 11. | “ | “ | 39 | “ | “ | “ | “ | “ | “ | “ | “ | 33 | “ |
| 12. | “ | “ | 8 | “ | “ | “ | “ | “ | “ | “ | “ | 11 | “ |
| 13. | “ | “ | 1½ | “ | “ | “ | “ | “ | “ | “ | “ | 2½ | “ |
| 14. | “ | “ | 45 | “ | “ | “ | “ | “ | “ | “ | “ | 39 | “ |
| 15. | “ | “ | 55 | “ | “ | “ | “ | “ | “ | “ | “ | 65 | “ |
| 16. | “ | “ | 8 | “ | “ | “ | “ | “ | “ | “ | “ | 5 | “ |
| 17. | “ | “ | ½ | “ | “ | “ | “ | “ | “ | “ | “ | 1½ | “ |

### Second Sitting

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18. | Test-tube | with | 33 | drops | of | solution | shown | first, | then | test-tube | with | 39 | drops |
| 19. | “ | “ | 65 | “ | “ | “ | “ | “ | “ | “ | “ | 55 | “ |
| 20. | “ | “ | 60 | “ | “ | “ | “ | “ | “ | “ | “ | 70 | “ |
| 21. | “ | “ | 11 | “ | “ | “ | “ | “ | “ | “ | “ | 8 | “ |
| 22. | “ | “ | 28 | “ | “ | “ | “ | “ | “ | “ | “ | 23 | “ |
| 23. | “ | “ | 3½ | “ | “ | “ | “ | “ | “ | “ | “ | 5 | “ |
| 24. | “ | “ | 20 | “ | “ | “ | “ | “ | “ | “ | “ | 17 | “ |
| 25. | “ | “ | 3½ | “ | “ | “ | “ | “ | “ | “ | “ | 2½ | “ |
| 26. | “ | “ | 24 | “ | “ | “ | “ | “ | “ | “ | “ | 20 | “ |
| 27. | “ | “ | 28 | “ | “ | “ | “ | “ | “ | “ | “ | 24 | “ |
| 28. | “ | “ | 17 | “ | “ | “ | “ | “ | “ | “ | “ | 14 | “ |
| 29. | “ | “ | 55 | “ | “ | “ | “ | “ | “ | “ | “ | 45 | “ |
| 30. | “ | “ | 5 | “ | “ | “ | “ | “ | “ | “ | “ | 3½ | “ |
| 31. | “ | “ | 20 | “ | “ | “ | “ | “ | “ | “ | “ | 24 | “ |
| 32. | “ | “ | 2½ | “ | “ | “ | “ | “ | “ | “ | “ | 1½ | “ |
| 33. | “ | “ | 17 | “ | “ | “ | “ | “ | “ | “ | “ | 20 | “ |
| 34. | “ | “ | 14 | “ | “ | “ | “ | “ | “ | “ | “ | 17 | “ |

bringing up plate cover 3. As in the training, the judgment was given in terms of the second stimulus. The subject would say "darker," meaning that he thought it was more saturated than the first test-tube shown; or "lighter," meaning less saturated. To get the reaction time, the lip-key and chronoscope were again used. Three tungsten lights of 40 watts each were arranged behind a large plate of milk glass (9) so that a uniformly illuminated background was given to the test tubes. All other lights were removed from the inside of the canopy which covered the experiment table.

The result of this test is presented in Table 8. While the trained group shows only a slight improvement in right judgments, the untrained group shows an improvement of 25 per cent more. This can only be accounted for by the increased reaction time of the untrained group. It confirms our finding in the training, namely that the way to reduce the number of wrong judgments in sense discrimination is to lengthen the reaction time. It will be noticed that the loss was greatest in the reaction time of wrong judgments in the untrained group. This indicates that these subjects employed more time in judging difficult cases of comparison. Whenever this was done, here or in the training, the number of wrong judgments was always smaller. Subjects VIII, X, and XIII reduced their number of wrong judgments considerably by lengthening their reaction time two or three fold in the final test. With Subject XI the lengthening of reaction time was not found, though her improvement was the greatest of all. This is because in her preliminary test she had a number of long reaction times due to difficulty in using the lip-key and these longer times have increased her average reaction time unduly.

TABLE 8

*Number of Wrong Judgments and Reaction Time in Discriminating Different Saturations of Orange*

| | | Preliminary Test | | | | Final Test | | | | Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Trained Group | I | 7 | 2127 | 2412 | 2075 | 7 | 1485 | 1581 | 1793 | 0 | 642 | 831 | 282 |
| | II | 10 | 1133 | 1117 | 1171 | 10 | 1469 | 1471 | 1464 | 0 | —336 | —354 | —293 |
| | III | 12 | 967 | 1017 | 823 | 12 | 884 | 720 | 1063 | 0 | 83 | 297 | —240 |
| | IV | 11 | 1012 | 886 | 1186 | 11 | 854 | 750 | 1071 | 0 | 158 | 136 | 115 |
| | V | 12 | 1114 | 1120 | 1110 | 13 | 1116 | 1058 | 1205 | —1 | —2 | 62 | 95 |
| | VI | 12 | 1285 | 1320 | 1222 | 10 | 1184 | 1322 | 843 | 2 | 101 | —2 | 379 |
| | VII | 8 | 1819 | 1741 | 2071 | 8 | 1843 | 2046 | 1682 | 0 | —24 | —305 | 389 |
| | Total | 72 | 9457 | 9613 | 9658 | 71 | 8835 | 8948 | 9121 | 1 | 622 | 665 | 537 |
| | Per cent. | | | | | | | | | 1.39 | 6.58 | 6.92 | 5.56 |
| | Average | 10.3 | 1351 | 1373 | 1380 | 10.1 | 1262 | 1278 | 1303 | | | | |
| Untrained Group | VIII | 13 | 810 | 887 | 685 | 9 | 1557 | 1323 | 2207 | 4 | —747 | —436 | 1522 |
| | IX | 9 | 1783 | 1677 | 2077 | 7 | 1603 | 1766 | 1731 | 2 | 180 | -89 | 346 |
| | X | 14 | 229 | 243 | 216 | 10 | 913 | 906 | 933 | 4 | —684 | —663 | —717 |
| | XI | 17 | 2249 | 2352 | 2098 | 8 | 1584 | 1525 | 1776 | 9 | 665 | 827 | 322 |
| | XII | 11 | 2019 | 1951 | 2071 | 14 | 1782 | 1790 | 1719 | —3 | 237 | 161 | 352 |
| | XIII | 8 | 1035 | 1014 | 1105 | 5 | 1084 | 1022 | 1444 | 3 | —49 | —8 | —339 |
| | Total | 72 | 8125 | 8124 | 8252 | 53 | 8523 | 8332 | 9810 | 19 | —398 | —208 | 1558 |
| | Per cent. | | | | | | | | | 26.39 | —4.90 | —2.56 | —18.88 |
| | Average | 12 | 1354 | 1354 | 1375 | 9 | 1420 | 1389 | 1635 | | | | |
| | Per cent. of Transfer | | | | | | | | | —25.00 | 11.48 | 9.48 | 24.44 |
| Control Group | XIV | | | | | 8 | 1235 | 1217 | 1295 | | | | |
| | XV | | | | | 5 | 574 | 655 | 524 | | | | |
| | XVI | | | | | 11 | 2312 | 2212 | 2522 | | | | |
| | Total | | | | | 24 | 4121 | 4084 | 4341 | | | | |
| | Average | | | | | 8 | 1374 | 1361 | 1447 | | | | |

Column 1—Subjects.
Columns 2, 6, 10—Number of wrong judgments.
Columns 3, 7, 11—Total average reaction time.
Columns 4, 8, 12—Average reaction time of right judgments.
Columns 5, 9, 13—Average reaction time of wrong judgments.

The question naturally arises: Why did not the subjects of the trained group use more time, after having had the special benefit of the training? The answer is that the subjects of the trained group were growing tired of the experiment; its novelty was lost in the three months' training. They seemed to be unwilling to give the necessary time needed to visual adaptation, and in many cases they seemed to have left it to chance whether they were right or wrong in their judgments. On the other hand, the subjects of the untrained group seemed to be only too glad to have a change in their daily program, to come to the experiment room once more, especially at the beginning of the retest. In none of the tests, preliminary or final, were the subjects of either group told of the rightness or wrongness of their judgments, as were the members of the trained group in the course of their training. This only made the trained group all the more unconcerned at the beginning of the retest. In a word, interest is quite essential for success in sense discrimination in children, for they must be willing to give their time for purposes of sensory adaptation.

### *Summary for Discrimination of Color*

1. This test confirms the finding in the training, that lengthened reaction time is the means to reduce the number of wrong judgments in visual discrimination.

2. Interest is essential for sense discrimination in children that they may give the time necessary for better visual adaptation.

### *3. Discrimination of Size*

The tested functions included not only discriminations of color and pitch but also discriminative functions more closely related to those in which training had been given. The subjects had been trained in discriminating vertical lines ranging from 1⅓ to 1⅔ inches long with a difference of 1/30 of an inch. Before and after this training, a test was taken not only with the same sizes as in the training, but also with one set of larger sizes, ranging from 2 1/10 to 2⅗ inches, and one set of smaller sizes, ranging from ¾ to 1 inch. These different sizes were also drawn in different forms, namely, as circles, triangles and horizontal lines as well as vertical lines. The differences to be discriminated in these various sizes were not the same; in the size ranging from 2 1/10 to 2⅗ inches, the difference to be discriminated was 1/10 of an inch; for the size ranging from ¾ to 1 inch, 1/20 of an inch; and from 1⅓ to 1⅔ inches, the same size in which training has been given, there were two sets of differences to be discriminated—one set, which included all the various forms, had a difference of 1/15 of an inch; the other, which included only the circles, triangles and horizontal lines, had a difference of 1/30 of an inch. Vertical lines with a difference of 1/30 of an inch were used only for the training and were excluded from the testing. Table 9 gives in detail the various sizes in different forms with the various differences to be discriminated.

It will be noticed that the trained function differed from the "a" series only in form, from the "A," "B," and "C" series of the vertical lines only in size and differences to be discriminated, from all the "B" series of circles, triangles and horizontal lines only in

TABLE 9

*Tested Functions. The Forms, Sizes, and Differences to be Discriminated*

| Forms | | No. of trials, or judgments | Differences to be discriminated[1] | No. of cards used | Sizes |
|---|---|---|---|---|---|
| Circles | A | 10 | 1/10 of an inch | 6 | ranging from 2 1/10 to 2 3/5 inches |
| " | B | " | 1/15 " " " | " | " " 1 1/3 " 1 2/3 " |
| " | C | " | 1/20 " " " | " | " " 3/4 " 1 " |
| Triangles | A | " | 1/10 " " " | " | " " 2 1/10 " 2 3/5 " |
| " | B | " | 1/15 " " " | " | " " 1 1/3 " 1 2/3 " |
| " | C | " | 1/20 " " " | " | " " 3/4 " 1 " |
| Vertical lines | A | " | 1/10 " " " | " | " " 2 1/10 " 2 3/5 " |
| " " | B | " | 1/15 " " " | " | " " 1 1/3 " 1 2/3 " |
| " " | C | " | 1/20 " " " | " | " " 3/4 " 1 " |
| Horizontal lines | A | " | 1/10 " " " | " | " " 2 1/10 " 2 3/5 " |
| " " | B | " | 1/15 " " " | " | " " 1 1/3 " 1 2/3 " |
| " " | C | " | 1/20 " " " | " | " " 3/4 " 1 " |
| Circles | a | 20 | 1/30 " " " | 11 | " " 1 1/3 " 1 2/3 " |
| Triangles | a | " | " " " " | " | " " 1 1/3 " 1 2/3 " |
| Horizontal lines | a | " | " " " " | " | " " 1 1/3 " 1 2/3 " |
| Vertical lines | | (training) | " " " " | " | " " 1 1/3 " 1 2/3 " |

[1] With circles the difference is in the diameter; with triangles, equally in the three sides.

form and differences to be discriminated, and from all the "A" and "C" series in size, form and differences to be discriminated. It is easily seen, with this arrangement, that the vertical line series was most closely related to the trained function, next came logically the horizontal lines, the triangles and circles, in accordance to form; with reference to size, that ranging from $1\frac{1}{3}$ to $1\frac{2}{3}$ inches was the most closely related to the training, next came that ranging from $\frac{3}{4}$ to 1 inch and $2\frac{1}{10}$ to $2\frac{3}{5}$ inches; and according to the differences to be discriminated, $\frac{1}{30}$, $\frac{1}{20}$, $\frac{1}{15}$ and $\frac{1}{10}$ of an inch, in the order stated.

There were altogether 15 series in this test, as shown in Table 9, making 15 sittings for each subject. These subjects came into the experiment room in turn for fifteen minutes in the morning on school days and made ten or twenty judgments in accordance with the different series. The order in which the various series followed each other was the same as shown in Table 9. The preliminary test lasted from November 4 to December 17, 1913, the final from April 28 to May 17, 1914. Much less time was taken during the final test, because of the dropping out of four subjects from the trained group and five from the untrained group. The hours of experiment for each subject were kept as nearly as possible the same in both tests. The general method and apparatus used in this test were the same as those used in the training.

The results of the test are presented in Tables 10, 11, 12, 13, and 14. Table 10 shows in detail how the percentages of transfer were calculated. What each column in the table stands for is explained in footnotes immediately following the table. The various amounts of transfer are rearranged in Table 11 so as to present

TABLE 10

*Total Number of Wrong Judgments, Reaction Time, and Percentage of Transfer in the Test of Discriminating Different Sizes*

| | Preliminary Test | | | | | Final Test | | | | Percentage of Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | | | | | | Circles, A series, 10 trials | | | | | | | |
| Trained | 7 | 7 | 8272 | 7975 | 10487 | 11 | 10006 | 9093 | 11621 | —57.14 | —20.96 | —14.02 | —10.81 |
| Untrained | 6 | 14 | 11133 | 11118 | 11954 | 2 | 10311 | 9868 | 13842 | 85.71 | 7.38 | 11.24 | —15.80 |
| Transfer | | | | | | | | | | —142.85 | —28.34 | —25.26 | 5.01 |
| | | | | | | Circles, B series, 10 trials | | | | | | | |
| Trained | 7 | 10 | 7897 | 7740 | 9790 | 9 | 10411 | 9755 | 11276 | 10.00 | —31.83 | —26.03 | —15.19 |
| Untrained | 6 | 8 | 10994 | 10551 | 12860 | 13 | 9994 | 9183 | 12324 | —62.50 | 9.10 | 12.96 | 4.17 |
| Transfer | | | | | | | | | | 72.50 | —40.93 | —38.99 | —19.36 |
| | | | | | | Circles, C series, 10 trials | | | | | | | |
| Trained | 7 | 13 | 8834 | 8039 | 10553 | 9 | 9326 | 9161 | 10165 | 30.77 | —5.57 | —13.96 | 3.67 |
| Untrained | 6 | 11 | 8938 | 8362 | 9796 | 9 | 9283 | 9124 | 11262 | 18.18 | —3.86 | —9.11 | —14.97 |
| Transfer | | | | | | | | | | 12.59 | —1.71 | —4.89 | 18.64 |
| | | | | | | Triangles, A series, 10 trials | | | | | | | |
| Trained | 7 | 18 | 9415 | 8644 | 10544 | 12 | 11826 | 11704 | 12279 | 33.33 | —25.61 | —35.40 | —16.46 |
| Untrained | 6 | 10 | 9915 | 9289 | 10720 | 10 | 9356 | 9134 | 9726 | 0 | 5.64 | 1.67 | 9.27 |
| Transfer | | | | | | | | | | 33.33 | —31.25 | —37.07 | —25.73 |
| | | | | | | Triangles, B series, 10 trials | | | | | | | |
| Trained | 7 | 16 | 8747 | 8210 | 11110 | 14 | 8785 | 8507 | 10197 | 12.50 | —.43 | —3.62 | 8.22 |
| Untrained | 5 | 10 | 7627 | 7457 | 7548 | 12 | 7627 | 7567 | 7920 | —20.00 | 0 | —1.48 | —4.93 |
| Transfer | | | | | | | | | | 32.50 | —.43 | —2.14 | 13.15 |
| | | | | | | Triangles, C series, 10 trials | | | | | | | |
| Trained | 7 | 9 | 7673 | 7260 | 9058 | 13 | 8522 | 9634 | 8576 | —44.44 | —11.07 | —32.70 | 5.32 |
| Untrained | 5 | 9 | 8569 | 8663 | 10070 | 14 | 7662 | 7915 | 6688 | —55.55 | 10.58 | 8.64 | 33.58 |
| Transfer | | | | | | | | | | 11.11 | —21.65 | —41.34 | —28.26 |

TABLE 10—*Continued*

*Total Number of Wrong Judgments, Reaction Time, and Percentage of Transfer in the Test of Discriminating Different Sizes*

| | Preliminary Test | | | | Final Test | | | | | Percentage of Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Vertical lines, A series, 10 trials | | | | | | | | | | | | | |
| Trained | 7 | 16 | 8618 | 8478 | 8989 | 14 | 10286 | 9580 | 11756 | 12.50 | —19.36 | —13.00 | —30.78 |
| Untrained | 5 | 17 | 11062 | 11451 | 11455 | 13 | 9001 | 9302 | 7590 | 23.53 | 18.63 | 18.77 | 33.74 |
| Transfer | | | | | | | | | | —11.03 | —37.99 | —31.77 | —64.52 |
| Vertical lines, B series, 10 trials | | | | | | | | | | | | | |
| Trained | 7 | 9 | 8807 | 8764 | 8860 | 3 | 8548 | 8340 | 9041 | 66.67 | 2.94 | 4.84 | —2.04 |
| Untrained | 5 | 10 | 7253 | 6699 | 11537 | 7 | 6992 | 6665 | 9463 | 30.00 | 3.60 | .51 | 17.98 |
| Transfer | | | | | | | | | | 36.67 | — .66 | 4.33 | —20.02 |
| Vertical lines, C series, 10 trials | | | | | | | | | | | | | |
| Trained | 7 | 20 | 8386 | 7499 | 11494 | 15 | 10964 | 10687 | 11700 | 25.00 | —30.74 | —42.51 | —2.66 |
| Untrained | 5 | 8 | 7624 | 7486 | 8419 | 12 | 7177 | 6600 | 7575 | —50.00 | 5.86 | 10.02 | 11.14 |
| Transfer | | | | | | | | | | 75.00 | —36.60 | —52.56 | —13.80 |
| Horizontal lines, A series, 10 trials | | | | | | | | | | | | | |
| Trained | 7 | 17 | 7615 | 7329 | 7274 | 21 | 9539 | 9441 | 9883 | —23.53 | —25.26 | —28.84 | —35.87 |
| Untrained | 5 | 14 | 7636 | 7674 | 10600 | 11 | 8593 | 7445 | 11379 | 21.43 | —12.53 | 2.98 | —7.35 |
| Transfer | | | | | | | | | | —44.96 | —12.73 | —31.82 | —28.52 |
| Horizontal lines, B series, 10 trials | | | | | | | | | | | | | |
| Trained | 7 | 13 | 8252 | 8168 | 8803 | 24 | 9482 | 9665 | 10374 | —84.62 | —14.90 | —18.33 | —17.85 |
| Untrained | 5 | 15 | 8983 | 8008 | 11729 | 16 | 7727 | 7047 | 9163 | —6.67 | 13.98 | 11.98 | 21.88 |
| Transfer | | | | | | | | | | —77.95 | —28.88 | —30.31 | —39.73 |
| Horizontal lines, C series, 10 trials | | | | | | | | | | | | | |
| Trained | 7 | 16 | 6932 | 6726 | 7545 | 14 | 9863 | 10086 | 8930 | 12.50 | —42.38 | —49.96 | —18.36 |
| Untrained | 5 | 12 | 7725 | 7969 | 7234 | 13 | 7122 | 7227 | 7208 | —8.33 | 7.81 | 9.31 | .04 |
| Transfer | | | | | | | | | | 20.83 | —50.19 | —59.27 | —18.40 |

TABLE 10—*Continued*

*Total Number of Wrong Judgments, Reaction Time, and Percentage of Transfer in the Test of Discriminating Different Sizes*

| | Preliminary Test | | | | | Final Test | | | | Percentage of Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | | | | | | Circles, a. series, 20 trials | | | | | | | |
| Trained | 7 | 46 | 8069 | 7690 | 8919 | 27 | 9793 | 9356 | 10834 | 41.30 | —21.36 | —21.66 | —21.47 |
| Untrained | 6 | 41 | 10378 | 9595 | 12246 | 41 | 9485 | 9353 | 9865 | 0 | 8.60 | 2.52 | 19.44 |
| Transfer | | | | | | | | | | 41.30 | —29.96 | —24.18 | —40.91 |
| | | | | | | Triangles, a. series, 20 trials | | | | | | | |
| Trained | 7 | 43 | 7875 | 7736 | 7930 | 43 | 9203 | 9229 | 8686 | 0 | —16.86 | —19.30 | —9.53 |
| Untrained | 6 | 47 | 8271 | 8187 | 8003 | 45 | 8781 | 8616 | 9023 | 4.26 | —6.17 | —5.24 | —12.75 |
| Transfer | | | | | | | | | | —4.26 | —10.69 | —14.06 | 3.22 |
| | | | | | | Horizontal lines, a. series, 20 trials | | | | | | | |
| Trained | 7 | 50 | 7860 | 7843 | 8347 | 41 | 9395 | 9291 | 9731 | 18.00 | —19.53 | —18.45 | —16.58 |
| Untrained | 6 | 46 | 8289 | 7872 | 8731 | 46 | 8056 | 7866 | 8745 | 0 | 2.81 | .01 | —.16 |
| Transfer | | | | | | | | | | 18.00 | —22.34 | —18.46 | —16.42 |

Column 1—The trained or untrained group.
Column 2—Number of subjects in each group.
Columns 3 and 7—Total number of wrong judgments made within that series.
Columns 4 and 8—Average reaction time of each trial of the test.
Columns 5 and 9—Average reaction time of successful trials only.
Columns 6 and 10—Average reaction time of wrong judgments or unsuccessful trials.
Columns 3, 4, 5 and 6—Record of the preliminary test.
Columns 7, 8, 9 and 10—Record of the final test.
Columns 11, 12, 13 and 14—Percentages of improvement in the final test.
Column 11—Percentage of wrong judgments.
Column 12—Percentage of gain in average reaction time.
Column 13—Percentage of gain in average reaction time of successful judgments.
Column 14—Percentage of gain in average reaction time of wrong judgments.

the result more clearly. It will be noticed in Table 11 that, when the amount of transfer is arranged according to size, Series b, in which the range of size is the same as in the training, has only about 17 per cent of transfer, while Series c, which is smaller in size than that of the training material, has a larger amount of transfer, about 30 per cent. This is probably accounted for by the large amount of negative transfer of horizontal lines B in Series b. Training in judging vertical lines probably interferes with judging horizontal lines, as the same result is shown in Table 11, (2), where the amount of transfer is arranged according to form. In (2) also it seems clear that the vertical lines, in which form the training has been given, have the largest amount of transfer. In Table 11, (3), where the amount of transfer is arranged according to the differences to be discriminated, it is easy to see that those differences that are farther away from the training, difference of 1/10 or 1/15 of an inch, have a smaller amount of transfer, while those differences that are nearest to the training, 1/20 or 1/30 of an inch, have a larger amount of transfer. On the whole, it is safe to say that those series which are most closely related to the trained function in size, form and differences to be discriminated have a larger amount of transfer, with the exception of horizontal lines.

Table 12 is arranged to show how the wrong judgments were made and whether the training caused any change in making such judgments. It seems clear that all the groups have made more wrong judgments when the second stimulus was larger in size; that is to say, there is a tendency for all the subjects to underestimate the second stimulus. Or, in other words, when a visual stimulus is withdrawn, it will

TABLE 11

*Total Amount of Transfer, Arranged according to Size, Form, and the Magnitude of Differences to be Discriminated. From Table 10*

| 1 | | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| (1) Amount of transfer as arranged according to size | | | | | |
| (a) 2 1/10 to 2 3/5 inches. | | | | | |
| Circles | A | —142.85 | —28.34 | —25.26 | —5.01 |
| Triangles | " | 33.33 | —31.25 | —37.07 | —25.73 |
| Vertical lines | " | —11.03 | —37.99 | —31.77 | —64.52 |
| Horizontal lines | " | —44.96 | —12.73 | —31.82 | —28.52 |
| Total | | —165.51 | —110.31 | —125.92 | —113.76 |
| Average | | —41.38 | —27.58 | —31.48 | —28.44 |
| (b) 1 1/3 to 1 2/3 inches | | | | | |
| Circles | B | 72.50 | —40.93 | —38.99 | —19.36 |
| Triangles | " | 32.50 | —.43 | —2.14 | 13.15 |
| Vertical lines | " | 36.67 | —.66 | 4.33 | —20.02 |
| Horizontal lines | " | —77.95 | —28.88 | —30.31 | —39.73 |
| Circles | a | 41.30 | —29.96 | —24.18 | —40.91 |
| Triangles | " | —4.26 | —10.69 | —14.06 | 3.22 |
| Horizontal lines | " | 18.00 | —22.34 | —18.45 | —16.42 |
| Total | | 118.76 | —133.89 | —123.80 | —120.07 |
| Average | | 16.97 | —19.13 | —17.69 | —17.15 |
| (c) 3/4 to 1 inch | | | | | |
| Circles | C | 12.59 | —1.71 | —4.89 | 18.64 |
| Triangles | " | 11.11 | —21.65 | —41.34 | —28.26 |
| Vertical lines | " | 75.00 | —36.60 | —52.56 | —13.80 |
| Horizontal lines | " | 20.83 | —50.19 | —59.27 | —18.40 |
| Total | " | 119.53 | —110.15 | —158.06 | —41.82 |
| Average | | 29.88 | —27.54 | —39.51 | —10.45 |
| (2) Amount of transfer as arranged according to form | | | | | |
| (a) Circles | | | | | |
| Circles | A | —142.85 | —28.34 | —25.26 | 5.01 |
| " | B | 72.50 | —40.93 | —38.99 | —19.36 |
| " | C | 12.59 | —1.71 | —4.89 | 18.64 |
| " | a | 41.30 | —29.96 | —24.18 | —40.91 |
| Total | | —16.46 | —80.94 | —93.32 | —36.62 |
| Average | | —4.11 | —20.23 | —23.33 | 9.15 |
| (b) Triangles | | | | | |
| Triangles | A | 33.33 | —31.25 | —37.07 | —25.73 |
| " | B | 32.50 | —.43 | —2.14 | 13.15 |
| " | C | 11.11 | —21.65 | —41.34 | —28.26 |
| " | a | —4.26 | —10.69 | —14.06 | 3.22 |
| Total | | 72.68 | —64.02 | —94.61 | —37.62 |
| Average | | 18.17 | —16.00 | —23.65 | —9.40 |

TABLE 11—*Continued*

(2) Amount of transfer as arranged according to form

(c) Vertical lines

| | | | | | |
|---|---|---|---|---|---|
| Vertical lines | A | —11.03 | —37.99 | —31.77 | —64.52 |
| " " | B | 36.67 | —.66 | 4.33 | —20.02 |
| " " | C | 75.00 | —36.60 | —52.56 | —13.80 |
| Total | | 100.64 | —75.25 | —80.00 | —98.34 |
| Average | | 33.55 | —25.08 | —26.67 | —32.78 |

(d) Horizontal lines

| | | | | | |
|---|---|---|---|---|---|
| Horizontal lines | A | —44.96 | —12.73 | —31.82 | —28.52 |
| " " | B | —77.95 | —28.88 | —30.31 | —39.73 |
| " " | C | 20.83 | —50.19 | —59.27 | —18.40 |
| " " | a | 18.00 | —22.34 | —18.45 | —16.42 |
| Total | | —84.08 | —114.14 | —139.85 | —103.07 |
| Average | | —21.02 | —28.53 | —34.96 | —25.77 |

(3) Amount of transfer as arranged according to the differences to be discriminated

(a) Difference of 1/10 of an inch

| | | | | | |
|---|---|---|---|---|---|
| Circles | A | —142.85 | —28.34 | —25.26 | 5.01 |
| Triangles | " | 33.33 | —31.25 | —37.07 | —25.73 |
| Vertical lines | " | —11.03 | —37.99 | —31.77 | —64.52 |
| Horizontal lines | " | —44.96 | —12.73 | —31.82 | —28.52 |
| Total | | —165.51 | —110.31 | —125.92 | —113.76 |
| Average | | —41.38 | —27.58 | —31.48 | —28.44 |

(b) Difference of 1/15 of an inch

| | | | | | |
|---|---|---|---|---|---|
| Circles | B | 72.50 | —40.93 | —38.99 | —19.36 |
| Triangles | " | 32.50 | —.43 | —2.14 | 13.15 |
| Vertical lines | " | 36.67 | —.66 | 4.33 | —20.02 |
| Horizontal lines | " | —77.95 | —28.88 | —30.31 | —39.73 |
| Total | | 63.72 | —70.90 | —67.11 | —65.96 |
| Average | | 15.93 | —17.72 | —16.78 | —16.49 |

(c) Difference of 1/20 of an inch

| | | | | | |
|---|---|---|---|---|---|
| Circles | C | 12.59 | —1.71 | —4.89 | 18.64 |
| Triangles | " | 11.11 | —21.65 | —41.34 | —28.26 |
| Vertical lines | " | 75.00 | —36.60 | —52.56 | —13.80 |
| Horizontal lines | " | 20.83 | —50.19 | —59.27 | —18.40 |
| Total | | 119.53 | —110.15 | —158.06 | —41.82 |
| Average | | 29.88 | —27.54 | —39.51 | —10.45 |

(d) Difference of 1/30 of an inch

| | | | | | |
|---|---|---|---|---|---|
| Circles | a | 41.30 | —29.96 | —24.18 | —40.91 |
| Triangles | " | —4.26 | —10.69 | —14.06 | 3.22 |
| Horizontal lines | " | 18.00 | —22.34 | —18.45 | —16.42 |
| Total | | 55.04 | —62.99 | —56.69 | —54.11 |
| Average | | 18.35 | —21.00 | —18.90 | —18.04 |

Column 2—Transfer, percentage of wrong judgments.

Column 3— Transfer, percentage of average reaction time.

Column 4—Transfer, percentage of average reaction time of right judgments only.

Column 5—Transfer, percentage of average reaction time of wrong judgments only.

be imagined in the majority of cases larger than it really is. In regard to whether training has caused any changes in making the wrong judgments, the table has failed to show any marked difference between the trained and the untrained groups. Both groups have increased their number of over-estimations of the smaller stimulus—the trained, from 118 to 129 and the untrained, from 118 to 144—and have decreased their number of under-estimations of the larger stimulus—the trained, from 185 to 141 and the untrained from 154 to 120.

Table 13 gives the total average amount of transfer, taking the various series of tests as a whole. It is evident that the amount of transfer is small when compared with the length of time the subjects have been trained, in spite of the fact that these various series are very closely related to the function trained. Table 13 also indicates that the improvement due to transfer is largely a result of lengthened reaction time. The trained group gained 11.27 per cent of correct judgments at the expense of nearly 19 per cent of time. On the other hand, the untrained group, which did not lose any time, had a small amount of gain. With the control group, the average reaction time was even larger than that of the trained group in their final test, which may account for their making the lowest number of wrong judgments of all the three groups. The reason why the control group should have spent more time and made fewer wrong judgments is partly explained by the fact that they were more capable pupils and made fewer wrong judgments throughout all the tests. In addition to this, the test was more of a novelty to them than to the other two groups, and hence they were willing to give to the judgments the

full time that seemed to them necessary. Table 13 shows very plainly that, as the various series of the test went on, there was shown by all the three groups a general decrease of reaction time and an increase of wrong judgments. As in the training, this was an indication of lack of interest in the experiment. However, the decrease of reaction time can account for only part of the increase in wrong judgments as the various series went on. The smaller forms and the

TABLE 12

*Wrong Judgments Made by the Three Groups, Before and After Training*

| Column | | Preliminary Test | | | | Final Test | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Trained Group | | Untrained Group | | Trained Group | | Untrained Group | | Control Group | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Test Series | | | | | | | | | | | |
| Circle | A | 4 | 3 | 8 | 6 | 7 | 4 | 2 | 0 | 1 | 4 |
| Circle | B | 4 | 6 | 3 | 5 | 6 | 3 | 2 | 11 | 0 | 5 |
| Circle | C | 1 | 12 | 4 | 7 | 6 | 3 | 4 | 5 | 0 | 2 |
| Triangle | A | 9 | 9 | 3 | 7 | 9 | 3 | 6 | 4 | 2 | 3 |
| Triangle | B | 7 | 9 | 4 | 6 | 10 | 4 | 7 | 5 | 1 | 1 |
| Triangle | C | 3 | 6 | 4 | 5 | 10 | 3 | 10 | 4 | 3 | 1 |
| Vertical | A | 9 | 7 | 8 | 9 | 7 | 6 | 4 | 9 | 0 | 4 |
| Vertical | B | 4 | 5 | 5 | 5 | 2 | 1 | 5 | 2 | 0 | 1 |
| Vertical | C | 11 | 9 | 4 | 4 | 5 | 10 | 8 | 4 | 3 | 2 |
| Horiz. L. | A | 7 | 10 | 6 | 8 | 12 | 9 | 6 | 5 | 4 | 5 |
| Horiz. L. | B | 7 | 6 | 3 | 12 | 12 | 12 | 11 | 5 | 4 | 2 |
| Horiz. L. | C | 6 | 10 | 4 | 8 | 8 | 6 | 8 | 5 | 6 | 3 |
| Circle | a | 18 | 28 | 22 | 19 | 4 | 23 | 16 | 25 | 4 | 8 |
| Triangle | a | 16 | 27 | 25 | 22 | 14 | 30 | 30 | 15 | 12 | 7 |
| Horiz. L. | a | 12 | 38 | 15 | 31 | 17 | 24 | 25 | 21 | 13 | 12 |
| Total | | 118 | 185 | 118 | 154 | 129 | 141 | 144 | 120 | 53 | 60 |

Columns 1, 3, 5, 7, 9 indicate wrong judgments made when the second stimulus was smaller in size, or an over-estimation of the smaller stimulus.

Columns 2, 4, 6, 8, 10 indicate wrong judgments made when the second stimulus was larger in size, or an under-estimation of the larger stimulus.

The same arrangement is followed in the next table, 13.

TABLE 13

*Average Number of Wrong Judgments and Reaction Time of the Trained, the Untrained and the Control Groups, Both in the Preliminary and the Final Tests*

| | Preliminary Test | | | | Final Test | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Trained Group | | Untrained Group | | Trained Group | | Untrained Group | | Control Group | |
| Column | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Test Series | | | | | | | | | | |
| Cir. A | 1.00 | 1179 | 2.33 | 1856 | 1.57 | 1430 | .33 | 1719 | 1.67 | 2190 |
| Cir. B | 1.43 | 1129 | 1.33 | 1831 | 1.29 | 1487 | 2.13 | 1664 | 1.33 | 2208 |
| Cir. C | 1.86 | 1262 | 1.83 | 1489 | 1.29 | 1332 | 1.50 | 1547 | .67 | 2010 |
| Tri. A | 2.57 | 1330 | 1.67 | 1689 | 1.71 | 1652 | 1.67 | 1559 | 1.67 | 2470 |
| Tri. B | 2.29 | 1250 | 2.00 | 1525 | 2.00 | 1257 | 2.40 | 1525 | .67 | 1914 |
| Tri. C | 1.29 | 1096 | 1.80 | 1713 | 1.86 | 1217 | 2.80 | 1532 | 1.33 | 1814 |
| V. L. A | 2.29 | 1231 | 3.40 | 2212 | 2.00 | 1469 | 2.60 | 1800 | 1.00 | 1996 |
| V. L. B | 1.29 | 1257 | 2.00 | 1450 | .43 | 1221 | 1.40 | 1358 | .33 | 1370 |
| V. L. C | 2.86 | 1198 | 1.60 | 1525 | 2.14 | 1566 | 2.40 | 1435 | 1.67 | 1610 |
| H. L. A | 2.43 | 1088 | 2.80 | 1567 | 3.00 | 1364 | 2.20 | 1718 | 3.00 | 1402 |
| H. L. B | 1.86 | 1179 | 3.00 | 1796 | 3.43 | 1354 | 3.20 | 1545 | 2.00 | 1667 |
| H. L. C | 2.29 | 990 | 2.40 | 1545 | 2.00 | 1409 | 2.60 | 1424 | 3.00 | 1687 |
| Cir. a | 6.57 | 1172 | 6.83 | 1730 | 3.86 | 1499 | 6.83 | 1596 | 4.00 | 1254 |
| Tri. a | 6.14 | 1125 | 7.83 | 1378 | 6.14 | 1315 | 7.50 | 1465 | 6.33 | 1619 |
| H. L. a | 7.14 | 1122 | 7.67 | 1381 | 5.71 | 1342 | 7.67 | 1311 | 8.33 | 1534 |
| Total | 43.31 | 17608 | 48.49 | 24687 | 38.43 | 20914 | 47.23 | 23198 | 37.00 | 26745 |
| Percentage of improvement | | | | | 11.27 | —18.77 | 2.60 | 6.03 | | |
| Percentage of transfer | | | | | 8.67 | —24.80 | | | | |

Columns 1, 3, 5, 7, 9 indicate the average individual number of wrong judgments in the various series tested.
Columns 2, 4, 6, 8, 10 indicate the average individual reaction time of the various series tested.

smaller differences to be discriminated also caused an increased number of wrong judgments. The "a" series, having the smallest differences to be discriminated, had the largest number of wrong judgments. Since all the "a" series had 20 trials while the other series had 10, divide by two to compare with the rest.

### *Summary for Discrimination of Size*

1. When the tested function was closely related to the trained function, within the field of visual discrimination, there was a small amount of transfer.

2. The larger amounts of transfer took place with those series which were most closely related to the trained function in form, size, and magnitude of differences to be discriminated.

3. There was an indication that training in the discrimination of vertical lines interfered with the discrimination of horizontal lines.

4. There was a tendency to underestimate the second stimulus in judging sizes ranging from ¾ to 2⅗ inches.

5. The amount of interest children showed in sense discrimination had something to do with the number of successful judgments.

6. The number of wrong judgments increased as the magnitude of the differences to be discriminated grew smaller.

7. The various series of the final tests again confirmed our finding in the training, that improvement in visual discrimination is largely a function of reaction time. If the subject lengthened the reaction time, he decreased the number of wrong judgments, and vice versa.

## Experiment 2

The second experiment was conducted at the same school and at the same time as the first experiment, with different subjects from the same grades. Table 14 shows the age, teachers' estimate of this group of subjects, and mental improvement from 1911 to 1912 according to the Binet tests.

TABLE 14

| Subject | Age in Jan., 1914 | Teachers' Estimate | Mental Improvement 1911 to 1912 |
|---|---|---|---|
| XVII | 9 | good | 1.4 years |
| XVIII | 12 | average | 1.2 " |
| XIX | 10 | good | 1.2 " |
| XX | 10 | average | 1.4 " |
| XXI | 13 | average | .0 " |
| XXII | 11 | average | .6 " |
| XXIII | 12 | good | .8 " |
| XXIV | 10 | good | 1.4 " |
| XXV | 11 | average | .8 " |
| XXVI | 10 | good | .8 " |
| Average | 10.8 | | .96 " |

For the preliminary and final tests a printed page of nonsense words of three letters each was used. Each subject came into the experiment room in the morning on one of the school days, sat down at the desk and was shown a paper with a written alphabet. This alphabet was divided into two parts, from *a* to *m* and from *n* to *z*, thus:

a b c d e f g h i j k l m
n o p q r s t u v w x y z

The subject memorized the letters belonging to each half of the alphabet for about three minutes, after which he was given a page of the nonsense words and

TABLE 15

*Improvement in Training of Ten Subjects in Underlining Words. First and Last Five Minutes' Record Compared*

| | First 5 Minutes | | | | | Last 5 Minutes | | | | Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| XVII | 30 | 13 | 1 | 0 | 29 min. | 68 | 55 | 0 | 0 | 38 | 42 | 1 | 0 |
| XVIII | 52 | 14 | 20 | 0 | 29 " | 99 | 43 | 16 | 1 | 47 | 29 | 4 | —1 |
| XIX | 35 | 13 | 2 | 1 | 24 " | 96 | 39 | 23 | 0 | 61 | 26 | —21 | 1 |
| XX | 100 | 55 | 2 | 5 | 25 " | 111 | 54 | 6 | 0 | 11 | —1 | —4 | 5 |
| XXI | 38 | 16 | 7 | 8 | 25 " | 96 | 16 | 42 | 1 | 58 | 0 | —35 | 7 |
| XXII | 128 | 29 | 46 | 5 | 25 " | 109 | 20 | 49 | 0 | —19 | —9 | —3 | 5 |
| XXIII | 69 | 32 | 13 | 0 | 21 " | 85 | 51 | 7 | 0 | 16 | 19 | 6 | 0 |
| XXIV | 47 | 30 | 3 | 1 | 26 " | 123 | 73 | 1 | 2 | 76 | 43 | 2 | —1 |
| XXV | 57 | 13 | 23 | 1 | 33 " | 101 | 34 | 23 | 2 | 44 | 21 | 0 | —1 |
| XXVI | 69 | 38 | 5 | 1 | 21 " | 161 | 104 | 2 | 0 | 92 | 66 | 3 | 1 |
| Total | 625 | 253 | 122 | 22 | 258 " | 1049 | 489 | 169 | 6 | 424 | 236 | —47 | 16 |
| Average | | | | | 25.8 min. | | | | | | | | |
| Percentage of Improvement | | | | | | | | | | 67.84 | 93.28 | —38.52 | 72.72 |

Column 1—Subjects.
Columns 2, 7, 11—Number of words covered.
Columns 3, 8, 12—Number of words correctly marked.
Columns 4, 9, 13—Errors of omission.
Columns 5, 10, 14—Errors of commission.
Column 6—Total amount of training each subject received.

TABLE 16

*Improvement of Last Ten Minute Test over that of the First One in Marking Letters of the Second Half of the Alphabet*

| | Preliminary Test | | | | Final Test | | | | Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| XVII | 143 | 59 | 6 | 2 | 176 | 74 | 1 | 2 | 33 | 15 | 5 | 0 |
| XVIII | 29 | 13 | 2 | 2 | 118 | 48 | 36 | 0 | 89 | 35 | —34 | 2 |
| XIX | 115 | 46 | 5 | 21 | 53 | 27 | 2 | 0 | —62 | —19 | 3 | 21 |
| XX | 306 | 117 | 31 | 3 | 212 | 91 | 11 | 1 | —94 | —26 | 20 | 2 |
| XXI | 125 | 51 | 9 | 20 | 192 | 79 | 41 | 10 | 67 | 28 | —32 | 10 |
| XXII | 89 | 39 | 7 | 22 | 167 | 69 | 12 | 22 | 78 | 30 | —5 | 0 |
| XXIII | 138 | 58 | 11 | 3 | 196 | 83 | 11 | 1 | 58 | 25 | 0 | 2 |
| XXIV | 160 | 65 | 3 | 4 | 206 | 90 | 9 | 2 | 46 | 25 | —6 | 2 |
| XXV | 82 | 34 | 14 | 14 | 273 | 113 | 57 | 8 | 191 | 79 | —43 | 6 |
| XXVI | 135 | 56 | 3 | 5 | 285 | 115 | 28 | 2 | 150 | 59 | —25 | 3 |
| Total | 1322 | 538 | 91 | 96 | 1878 | 789 | 208 | 48 | 556 | 251 | —117 | 48 |
| Percentage of improvement | | | | | | | | | 42.06 | 46.65 | —128.57 | 50.00 |

Column 1—Subjects.
Columns 2, 6, 10—Number of words covered.
Columns 3, 7, 11—Number of words correctly marked.
Columns 4, 8, 12—Errors of omission.
Columns 5, 9, 13—Errors of commission.

asked to underline words that contained either two or three letters in the last half of the alphabet, beginning from the top of the page. The operator watched the time. When ten minutes were up the subject stopped marking. The following three lines copied from the testing page will make the experiment clear:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| itp | dje | zna | dkt | giy | hkr | cbe | dby |
| vhl | xgt | hju | wdy | zxi | fgy | hkp | msj |
| vgr | fte | sdw | cng | bjy | dhe | cgx | zaq |

For training, a different page containing the same kind of nonsense words was used, but the subjects were asked to underline words containing either two or three letters in the first half of the alphabet. Each subject was trained three periods averaging about 8½ minutes each. The preliminary test took place in December, 1913, the training in January and February, 1914, and the final test in March, 1914. The interval between the dates of testing was two months and between each of the trainings was about 12 days for each subject. The improvement from the training is presented in Table 15.

The improvement of the final test over the preliminary test is shown in Table 16.

Table 16, however, does not show the amount of transfer from training, because the influence of the preliminary test has not been checked out. Owing to the limited number of subjects available, an untrained group was not provided for. The author assumed that the effect of the first training upon the second training would be about the same as the effect of the first or preliminary test upon the second or the final test. If this had been true, the difference between the first and the second training might have served as a substitute for a check by an untrained

group. This assumption was incorrect, because the interval between the preliminary and the final tests was about four times as long as the interval between each of the trainings. In accordance with the law of disuse therefore the function of marking the last half of the alphabet was more weakened than that of marking the first half. The amount of transfer certainly should be more than is shown in Table 17, just how much more the writer is unable to say.

For lack of a proper check of the influence of the preliminary test, the amount of transfer in the experiment is of little significance. However, there are other points of interest that this experiment has brought out.

In the first place, the quicker improvement in marking letters of the alphabet as compared with sense training deserves consideration. There was more improvement after two trainings in marking letters of the alphabet than there was after 40 trainings in discriminating differences of size. The introspection of the two trained groups throws some light on this point of difference. In the experiment with sense discrimination, when the subjects were asked to explain the reason of their improvement, four out of the seven subjects could not give any reason at all, while the other three merely stated: "I give them a good long look" (subject I), "I do not hurry myself to say 'shorter' or 'longer'" (Subject VI), "I looked at them harder and tried to keep the first figure in my head" (Subject VII). This indicates that the only device developed by the training was that of lengthening the reaction time. Only two out of seven subjects were even vaguely conscious that a longer time was necessary in order to judge more correctly. On the

## TABLE 17

### A.

*Amount of Improvement in the Second Ten Minute Training over the First Ten Minute Training in Marking Letters of the First Half of the Alphabet*

| | First 10 Min. Training | | | | Second 10 Min. Training | | | | Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| XVII | 61 | 36 | 5 | 0 | 146 | 81 | 5 | 0 | 85 | 45 | 0 | 0 |
| XVIII | 104 | 30 | 31 | 0 | 218 | 92 | 46 | 0 | 114 | 62 | —15 | 0 |
| XIX | 60 | 26 | 4 | 2 | 85 | 41 | 4 | 2 | 25 | 15 | 0 | 0 |
| XX | 249 | 143 | 6 | 4 | 221 | 130 | 4 | 1 | —28 | —13 | 2 | 3 |
| XXI | 82 | 29 | 22 | 9 | 107 | 32 | 30 | 8 | 25 | 3 | —8 | 1 |
| XXII | 198 | 38 | 80 | 5 | 371 | 54 | 65 | 0 | 173 | 16 | 15 | 5 |
| XXIII | 147 | 65 | 26 | 0 | 107 | 106 | 4 | 0 | —40 | 35 | 22 | 0 |
| XXIV | 95 | 60 | 3 | 4 | 176 | 120 | 2 | 6 | 81 | 60 | 1 | —2 |
| XXV | 129 | 27 | 45 | 3 | 121 | 42 | 36 | 4 | —8 | 15 | 9 | —1 |
| XXVI | 146 | 77 | 12 | 2 | 216 | 136 | 5 | 2 | 70 | 59 | 7 | 0 |
| Total | 1271 | 531 | 234 | 29 | 1768 | 828 | 201 | 23 | 497 | 297 | 33 | 6 |
| Percentage of Improvement | | | | | | | | | 39.10 | 55.93 | 14.10 | 20.69 |

Columns 1, 2, etc., as in Table 16.

### B.

*Amount of Transfer when the Influence of the Preliminary Test is Checked Out, the Difference of the First and the Second Training being taken as a Substitute*

| | Percentage of Words Covered | Percentage of Words Correctly Marked | Errors of Omission in Percentage | Errors of Commission in Percentage |
|---|---|---|---|---|
| Total improvement of final test, see table 16. | 42.06 | 46.65 | —128.57 | 50.00 |
| Difference of first and second ten minute training, table 17. | 39.10 | 55.93 | 14.10 | 20.69 |
| Amount of transfer | 2.96 | —9.28 | —142.67 | 29.31 |

other hand, every subject in the second experiment had something more or less definite to say when asked to give his reasons for improvement. "The two parts of the alphabet are more clear to me now, I can tell in which part almost every letter belongs" (Subject XXV). "There were a few letters which I was not sure where they belonged at first, now they do not trouble me very much" (Subject XXIV). These introspections were confirmed by their own records. XXV constantly omitted to underline words containing the letter *j* in the training and marked them wrongly in the tests, evidently thinking it belonged to the last half of the alphabet. XXIV had similar trouble with the letters *j* and *k*. XXIII was troubled with the letter *j* and XXVI with the letter *k*. These were the subjects who made mistakes consistently when a certain letter or letters were found in the words. Why should *j* and *k* be placed in the second half of the alphabet instead of *l* and *m*, which are nearer to the second half of the alphabet than they? If this was not a mere accident, the writer suspects it was because when children were taught the alphabet, *k* was often made the stopping place for breath, while *l* and *m* were often grouped with *n-o-p*, and *j* and *k*, being thus placed at the end of a group of letters, would probably be felt to be later in the alphabet than they really are. To go on with the introspection, "I do not need to repeat the alphabet as much as I did at the beginning, in order to place a letter where it belonged" (Subject XIX). "The places of the letters are now clearer to me" (Subject XXI). "I have got a way to find whether a letter belongs to the first half of the alphabet, to join that letter with another letter which I am sure belongs to either part of the alphabet by repeating

other letters around it" [by repeating the alphabet] (Subjects XVII and XVIII). It seems clear from these introspections that, first, every subject realized that the means of success depended upon the right placing of the letters into the two halves; and second, at least three methods were developed to accomplish this purpose: namely, each letter was recognized independently as to the half in which it belonged; the alphabet was repeated as a whole, or in groups; or a letter was associated with other letters of the position of which the subject was sure. It seems that the quicker improvement in the second experiment is accounted for by the realization of where the difficulty of the problem lies and by the greater possibilities of developing methods to meet this difficulty. In discriminating size the means for better success were not easily realized and the possibility of developing methods was very limited. Subjects XVII, XVIII and XX had no method whatever at the beginning of the test. During the first test, as well as in the first training, they often stopped and looked up into the air, scratched their heads, stretched their legs, or tapped their teeth with the pencil. Toward the last of the experiment these signs all stopped, when each had a "way" of placing the letters. Method is an important aid to quick improvement. This point has already been brought out by Ruger in his experiment on the solving of puzzles.[20] The curve of learning rose suddenly whenever a successful method was hit upon. In our first experiment, which did not favor the development of methods, the improvement was slow, whereas in our second experiment, which was more favorable to the

[20] Ruger, H. A. The Psychology of Efficiency, *Archives of Psychology*, Vol. 2, No. 15, 1910.

development of methods, the improvement was much more rapid.

In the second place, the experiment shows that intelligence as manifested in school studies went with intelligence in marking letters. The five good pupils, as estimated by the teachers, contributed 69.10 per cent of the improvement in the number of words covered and 83.95 per cent of the improvement in the number of words correctly marked, while they contributed only 19.15 per cent of the omissions and 6.25 per cent of the commissions.

TABLE 18

*Amount of Improvement Contributed by the Good and Average Pupils.*

| | No. of Words Covered | No. of Words Correctly Marked | Errors of Omission | Errors of Commission |
|---|---|---|---|---|
| Good Pupils... | 293 or 69.10% | 196 or 83.05% | —9 or —19.15% | 1 or 6.25% |
| Average Pupils | 131 " 30.90% | 40 " 16.95% | —38 " —80.85% | 15 " 93.75% |
| Total....... | 424 " 100.00% | 236 " 100.00% | —47 " —100.00% | 16 " 100.00% |

## *Summary for Experiment 2*

1. Three trainings in marking letters of the alphabet have shown more improvement than 40 trainings in discriminating sizes ranging from ¾ to 2½ inches with differences to be discriminated ranging from 1/30 to 1/10 of an inch.

2. The different rate of improvement seemed to depend upon locating the difficulty of the problem and developing methods to meet the difficulty. If the difficulty of the problem was not easily localized and its nature not favorable for the development of methods, the rate of improvement was slow.

3. There was a positive correlation between success in school subjects and success in marking letters.

## Experiment 3

This experiment was conducted in the Psychological Laboratory of the University of Michigan in the summer of 1913. It consisted of marking five-lettered nonsense words of which the following three lines are samples:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| yabgt | bgtre | ojrns | mrjau | nruyt | nhygv | pkiuw | sdfgh | bytfd |
| zdtey | ngtew | pokmn | asdrt | dghtr | xdrty | qwerp | zsduy | iuytr |
| pkgds | asdew | werty | yfonk | cazpo | hjiow | qshru | jhgfr | ygvcd |

In the preliminary and final tests the subjects were asked to connect with a dash all pairs of adjacent words where one word contained three consecutive letters not found in the other. Beginning from the top of the page, the first word was compared with the second, then the second was compared with the third, and so on to the end of the line. The last word of each line was compared with the first word in the next. For the training, eight other pages with the same kind of nonsense words were prepared. Instead of marking words containing three consecutive letters that weie not the same, the subjects were asked to place a dash between two words which contained two adjacent letters that were in common. In the test the task was to ignore letters that were in common and attend to letters that were different and in the training the task was to ignore letters that were different and attend to those that were the same. Both tasks were to attend to certain letters and ignore others, the difference consisted in what letters to attend and what to ignore; thus the two activities were closely related.

The experiment was performed three times, each time with one trained subject and one or two untrained subjects. The following table furnishes important data regarding these subjects:

TABLE 19

*Standing of Subjects in Marking Five-Letter Nonsense Words*

| Subject | Part taken in experiment | Age in August, 1913 | Year in School |
|---|---|---|---|
| | | First Performance | |
| XXVII | Training and tests | 13 | Fourth grade |
| XXVIII | Tests only | 13.4 | " " |
| | | Second Performance | |
| XXIX | Training and tests | 15.1 | Sixth " |
| XXX | Tests only | 15.6 | Seventh " |
| | | Third Performance | |
| XXXI | Training and tests | 24.3 | Freshman, college |
| XXXII | Tests only | 26 | Senior, " |
| XXXIII | " " | 27.2 | Freshman, " |

All the work was done in the Psychological Laboratory at about 7 P. M. in the months of July and August, 1913. In each performance the trained and untrained subjects were tested together and during training the untrained subjects remained away. Table 20 gives the results of the training, and Table 21 the amount of transfer, of the three performances.

It will be noticed that the improvement in marking the letters of the alphabet shown by this experiment is again much greater than it was in sense discrimination. The introspections of the three trained subjects were especially enlightening. Subject XXVII: "At first, I could only compare the words letter by letter. Later on, I became so familiar with the work that I could compare two or three letters in the words all at once." Subject XXIX: "When I began this work, I had to compare words by groups of two or three [letters]. Now it seems that the letters that are the same in two words stand out more clearly. The only thing I have to do is to pick out the letters that are

## TABLE 20

*Amount of Improvement in Marking Five-Letter Nonsense Words that have Two Adjacent Letters in Common*

| | First 20 Minutes of Training | | | | | Last 20 Minutes of Training | | | | Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| XXVII | 92 | 34 | 10 | 0 | 55 | 158 | 49 | 16 | 0 | 66 | 15 | —6 | 0 |
| XXIX | 125 | 55 | 3 | 1 | 350 | 227 | 120 | 5 | 0 | 102 | 65 | —2 | 1 |
| XXXI | 110 | 50 | 3 | 0 | 182 | 281 | 134 | 5 | 0 | 171 | 84 | —2 | 0 |
| Total | 327 | 139 | 16 | 1 | 587 | 666 | 303 | 26 | 0 | 339 | 164 | —10 | 1 |
| Percentage of improvement | | | | | | | | | | 103.67 | 118.00 | —62.50 | 0 |

Column 1—Subjects.
Column 6—Amount of training received, in minutes.
Columns 2, 7, 11—Number of words covered.
Columns 3, 8, 12—Number of dashes rightly placed.
Columns 4, 9, 13—Number of omissions.
Columns 5, 10, 14—Number of commissions.

the same and then to see whether they are together or not." Subject XXXI: "For the first days I tried to compare the words as a whole and this was rather confusing. Later on, I happened to think there could be no possibility of the words having two adjacent letters in common if the three letters in the center of the two words were all different. Since that my attention has been directed more to the central letters of the words. Many words which usually wasted time were skipped this way." It became very evident from these introspections that the amount of improvement depended upon the methods that were employed. In spite of the fact that Subject XXIX had more training than XXXI, the latter showed a greater amount of improvement. This confirms our finding in the preceding experiment, that the methods employed are the primary factors determining amount of improvement.

By comparing the age of the different subjects it will be seen that the older subject always had the advantage over the younger subject in his ability to develop better time-saving methods. Even at the very beginning of the training there was a difference of method. Subject XXVII compared the words letter by letter; Subject XXIX, by groups of letters of two or three; and Subject XXXI, by whole words. This suggests that the older subject, having had more experience in reading, had already developed methods which the younger subject was not capable of at the start. This would indicate that there are certain "lower" methods which must be mastered before any "higher" methods can be attempted. In this particular case there are evidently three grades of methods, the letter method, the letter-group method and the

TABLE 21

*Total Amount of Transfer in Marking Two Adjacent Five-Letter Nonsense Words Having Three Consecutive Different Letters*

| | Preliminary Test | | | | Final Test | | | | Per cent of Improvement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| First Performance of the Experiment | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| XXVII | 69 | 15 | 8 | 13 | 62 | 20 | 7 | 23 | —10.15 | 33.33 | 12.50 | —76.92 |
| XXVIII | 36 | 13 | 1 | 9 | 41 | 12 | 3 | 9 | 13.89 | —7.69 | —200.00 | 0 |
| Transfer | | | | | | | | | —24.04 | 41.02 | 212.50 | —76.92 |
| Second Performance of the Experiment | | | | | | | | | | | | |
| XXIX | 160 | 38 | 0 | 6 | 197 | 55 | 4 | 0 | 23.13 | 44.74 | — ∞ | 100.00 |
| XXX | 130 | 42 | 1 | 27 | 105 | 26 | 7 | 9 | 19.23 | —38.10 | —600.00 | 66.67 |
| Transfer | | | | | | | | | 3.90 | 82.84 | | 33.33 |
| Third Performance of the Experiment | | | | | | | | | | | | |
| XXXI | 88 | 20 | 12 | 3 | 141 | 49 | 0 | 1 | 60.23 | 145.00 | 100.00 | 66.67 |
| XXXII | 142 | 48 | 3 | 17 | 211 | 64 | 5 | 22 | 48.60 | 33.33 | —66.67 | —29.42 |
| XXXIII | 105 | 35 | 0 | 50 | 142 | 48 | 3 | 5 | 35.24 | 37.14 | — ∞ | 90.00 |
| Total (XXXII + XXXIII) | | | | | | | | | 83.84 | 70.47 | | 60.58 |
| Average " " | | | | | | | | | 41.92 | 35.23 | | 30.29 |
| XXXI | | | | | | | | | 60.23 | 145.00 | 100.00 | 66.67 |
| XXXII and XXXIII | | | | | | | | | 41.92 | 35.23 | | 30.29 |
| Transfer | | | | | | | | | 18.31 | 109.77 | | 36.38 |

Column 1—Subjects.
Columns 2, 6, 10—Number of words covered.
Columns 3, 7, 11—Number of dashes correctly placed.
Columns 4, 8, 12—Number of omissions.
Columns 5, 9, 13—Number of commissions.

whole-word method. The older subject was able to develop more efficient methods, because he had already mastered the "lower" methods.

Table 21 reveals a regular increase in the amount of transfer from the first performance of the experiment to the last. The reason for this increase can be found from the introspections of the subjects after the final test. "I compared the words as they were in the practising pages (in letter groups of two or three). Only I look for letters that are different this time" (Subject XXVII). "I look first for the letters that are different and second to see whether they are connected" (Subject XXIX). "The central letters of the words to be compared are of great importance. If either of the central letters is found anywhere in the other word, there will be no possibility of having three consecutive letters that are mutually different. Time is thus saved" (Subject XXXI). It appears from these introspections that the different methods employed by the subjects fully account for the differences in the various amounts of transfer. Subject XXXI, who had the best time-saving method, also had the largest amount of transfer, while Subject XXVII, who had a method that was least advantageous in time-saving, had the smallest amount of transfer. Moreover, according to these introspections, all three subjects had slightly modified their methods brought over from the training, and in this modification Subject XXXI had again shown his superiority in making the most of his own method. This was his explanation: "In the practising pages, when the object was to look for consecutive letters that were in common, my method of attending to the three central letters of the words to be compared would have failed in a case like this:

a b c d e f g h e d. Though the three central letters were all different, yet there was the possibility of having two consecutive letters in common, namely, e d. For this reason I had to attend to the ends of the words more or less, and I did not have the full confidence in my method, as I had in that of the last test." The fact that he had the largest amount of transfer is thus explained.

*Summary for Experiment 3*

1. In marking five-letter nonsense words the amount of improvement depended directly upon the method that was developed in practice. This is but a repetition of the finding in the training of Experiment 2.

2. The older subjects showed a capacity for developing efficient methods decidedly superior to that of the younger subjects.

3. The means of transfer, in this experiment, were primarily the methods that were developed during the training and applied in the test, albeit these methods were sometimes modified in the test.

4. An adult subject was better able than a youth to apply his method in a changed situation.

5. The amount of transfer seemed to vary *pari passu* with the efficiency with which the method was applied in the changed situation.

## CONCLUSIONS

*1. Sense training.* Experiment 1 indicates that visual discrimination improves very slowly. This slowness is accounted for in two ways.

First, it is probably impossible to train any sense organ and secure much direct improvement in it, due to the limited number of the nerve endings. Since the rods and cones in the eyes of a person are determined at birth, no amount of training can create more of these nerve endings. According to the time record, we see plainly that the improvement in eliminating wrong judgments is largely a matter of visual adjustment. For, when the subjects spent more time in looking at the various shades of colors, forms and sizes, there was generally a decrease in the number of wrong judgments, and when the subjects tried to reduce their time, there was generally an increase in the number of wrong judgments. The very fact that to a certain amount of time corresponds a certain number of wrong judgments indicates that no change has taken place in the eyes and that a certain amount of time is necessary that they may see more clearly.

Second, the slow improvement may be attributed to the fact that the subjects never realized that they could see more correctly by using more time, so the difficulty of the whole situation was never localized. The fact that the reaction time had anything to do with the number of successful judgments had not only escaped the detection of the children in the experiment, but even adults on whom the training series was tried in the summer of 1913 were unable to explain why they made better scores on some days than on

others. During this training series there was one subject, an instructor in psychology, who had an idea that improvement always resulted in shortening the reaction time and tried definitely to reduce it. After five weeks of training his number of wrong judgments was slightly higher than at the time when he first started. The record was never shown to the subjects and it seemed that they were unable to appreciate the help which came from lengthening the reaction time from a quarter to a half of a second. The subjects in Experiment 1, being unable to localize the source of their faults, did not develop a method for improvement. In Experiments 2 and 3, on the other hand, the situation was altogether different. Here, in marking the letters of the alphabet, the subjects were able to recognize at once the difficulty to be overcome, whether it was to divide the alphabet into two halves, as in Experiment 2, or to attend to certain letters and to ignore others, as in Experiment 3. They were thus able to develop methods and improved quickly.

Sense training in Experiment 1 not only failed to bring about rapid specific improvement, but its effect on related functions was also small as compared with the effect upon the related functions of marking letters of the alphabet. Because the method of improvement in the training was not clearly recognized, there was made no purposive application in the test of methods developed in the training. For the same reason the amounts of transfer in Experiment 1 are also irregular and seem to be the work of chance, while in Experiment 3 the amounts of transfer are regular and proportionate to the efficiency of the methods employed. Sense training or the education of the senses is a misnomer. The Montessori method should better be

called education *through* the senses instead of "*of*" the senses. Montessori says:

"It is exactly in the repetition of the exercises that the education of the senses consists; their aim is not that the child shall *know* colors, forms and the different qualities of objects, but that he refine his senses through an exercise of attention, of comparison, of judgment. These exercises are true intellectual gymnastics."[21]

In this quotation there is some obscurity as to what is educated. Is it the senses, through an exercise of attention, of comparison, of judgment, or is it these intellectual functions through an exercise of the senses? Evidently it is the latter.

*2. Transfer.* This word, as commonly understood with reference to formal discipline, means the application of a habit or a method or an ideal to a situation other than the one in which it was developed. The use of the psychological term, habit, has been very unfortunate for "Upon the question of the possibility of transferring a specific habit from the situation in which it has been formed to another situation, there has been a great deal of controversy."[22] Bagley thinks that a generalized habit is impossible for "the term is a psychological absurdity. The very essence of a habit is the specific character of its response."[23] But Colvin asserts: "There seems to be no reason in the nature of the case, as far as the mechanism of the nervous system is concerned, however, why we may not think of several stimuli resulting in a particular response along a definite path of conduction, or, why,

[21] Montessori, M., *The Montessori Method*, p. 360.
[22] Colvin, S. S., and Bagley, W. C., *Human Behavior*, p. 181.
[23] Bagley, W. C., *The Educative Process*, p. 204.

on the other hand, we may not conceive of a single stimulus forming several passages of discharge."[24] Breed says this is a controversy over terms rather than facts. A habit is either specific or general according to the way one looks at it. Take, for instance, the habit of cleanliness. It is specific in the sense that it is a fixed response of avoidance when dirt is the stimulus. Dirt on the shoes, desk or floor may call up the attitude of repugnance. The habit may also be called general, if one regards the shoes, desk or floor as different situations. It seems to the writer that the term habit should be entirely avoided in the problem of transfer, for two reasons. First, transfer in many cases is a conscious process, that is, one applies purposively to one function a method developed in another. Second, in the application of the method there is generally a modification of it to suit the changed situation. Both consciousness and modifiability are characters lacking in a habit. Transfer of *method* is preferable to transfer of *habit.*

*3. Means of transfer.* It is interesting to note that in previous investigations experimenters have found more than one means of transfer.[25] The same thing was true of each of our experiments. In Experiment 1 the means is the lengthening of the reaction time; in Experiment 2, the dividing of the two halves of the alphabet; and in Experiment 3, the attending to a certain kind of letters and the ignoring of others. It is also of interest to note that the means of transfer used by each individual was also the method used by him for improvement in training. Since the experiments were concerned with different kinds of dis-

[24] Colvin, S. S., *The Learning Process*, p. 49.
[25] Colvin, S. S., *The Learning Process*, pp. 241-242.

crimination and the means of transfer in every case were conditioned by the method of improvement in the trained function, there can not be one means of transfer for all functions. The common character of the various means of transfer was that they were all some sort of method which was developed in the training for the purpose of improvement in it, and later on applied to changed situations.

*4. Amount of transfer.* Our experiments seem to indicate that the amount of transfer depends upon two factors: namely, purposive application of method and the efficiency of the method applied. In Experiment 1, none of the subjects was conscious that there was a method for improvement, consequently the amount of transfer was small. In the discrimination of size it amounted to only 8.67 per cent (Table 13). In Experiment 3, in the marking of letters (Table 21), wherein the subjects made purposive application of their methods, the amount of transfer was much larger. These facts seem to show that there is a possibility of having a certain amount of transfer without clearly recognizing the means of transfer, but a surer and larger amount can be brought about by having the means of transfer made conscious.

Experiment 3 shows plainly that the comparatively larger amounts of transfer in the last two performances are the result of more efficient methods. As has been pointed out in that experiment, the chance of getting hold of an efficient method depends upon two things—applicability of methods derived from experiences and the ability to apply. In both of these aspects an adult had the advantage over a youth.

With regard to the best way, therefore, to realize the formal value of a study, our experiments point to

the development of methods—methods for use in similar situations, efficient methods, methods consciously applied.

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